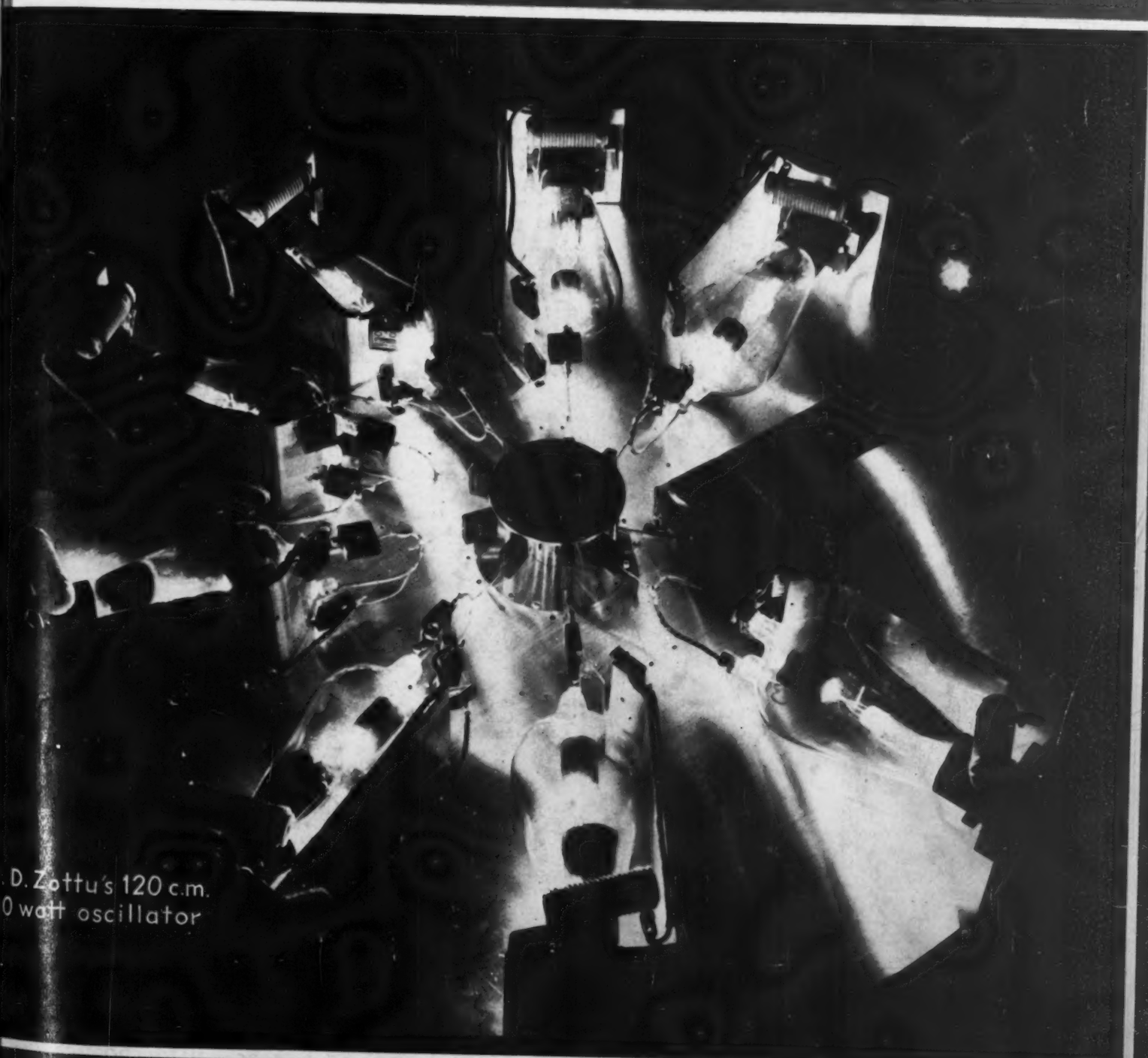
electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture



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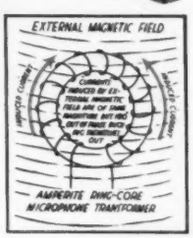

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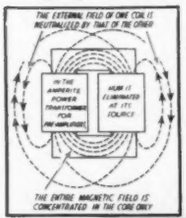
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ELECTRONICS

radio, communication and industrial applications of electron tubes . . . design, engineering, manufacture

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ELECTRONICS

JUNE
1936

KEITH HENNEY
Editor

Crosstalk

▶ **TELEVISION** . . . In this issue is presented an up-to-the-minute survey of television written as a result of conferences with men in each of the several laboratories actively engaged in bringing this new service into reality. All such men fear that the public will gather that television is imminent, that it is already frozen in its present technical tracks, that for some reason the "interests" are holding it back. None of this is true. Television is still some distance away, commercially, but the hopeful thing is that television is very definitely now on the way, commercially.

We have seen demonstrations of studio pickups, of street scenes, of football games transmitted from film. All were definitely interest-holding, indeed exciting. But there are many technical and commercial problems yet to be solved before, say a year and a half from now, New York City, and perhaps Philadelphia, can buy receivers for the home.

▶ **THUNDER WORSE THAN LIGHTNING** . . . Like the dog whose bark is worse than his bite, thunder and not lightning proved to be the disturbing factor in radio reception in the first storm of the season May 3—to those listening to Major Armstrong's frequency modulation system. Signals coming from W2AG on 2.5 meters, 11 miles away, 300 watts, were clear from noise while it was impossible to listen to the big stations on broadcast wavelengths. So strong was the local static that on a broadcast set with insulated tuning knobs held to the condenser shaft with a steel screw, each crash of static would make itself known to the listener by a sharp pinge of electric shock. On the strong crashes, only a slight "tick" was heard in the Major's receiver. Short waves and frequency modulation seems to be the answer.

▶ **COPS AND ROBBERS** . . . On May 22 Colonel H. Norman Schwartzkopf of the New Jersey State Police demonstrated a new adjunct to the identification of criminals. Portable sound motion picture apparatus, sight and sound, designed by RCA Victor engineers is the heart of this new implement in the war on crime. The equipment is made up of the camera, prefocused, the backdrop with canvas flooring indicating the proper positions of camera and subject, lights, etc. Thus the line-up, now seen by a few detectives, can be immeasurably increased in both the dimensions of time and space.

▶ **BIBLIOGRAPHY** . . . A reader, interested in the Massa series of articles on loud speakers, the first of which appeared in March and the second of which is in the works, cites two references which others intersted in loud speakers might consult. They are: "Sound Waves of Finite Amplitude in an Exponential Horn," by S. Goldstein and W. W. McLachlan, *Journal of the Acoustical Society of America*, April, 1935, page 275 and Thuras, Jenkins and O'Niel, "Extraneous Frequencies Generated in Air Carrying Intense Sound Waves," *Bell System Technical Journal*, January, 1935.

▶ **TUBES HELP MAKE AUTOS** . . . A second article by Ralph Powers of Detroit who is going great guns in equipping various automobile plants with electronic apparatus points out the backwardness of radio—while every day we hear of new applications of tubes to the manufacture of automobiles we have yet to hear of a new use of tubes in a radio plant which has gone into service during the last year. We do not believe this is because radio plants are already well equipped with electronic apparatus but merely that radio men are so close to the woods they can't see the trees.

▶ **SUPERSONICS** . . . Recent interest in vibrations beyond the audible range indicates that a new agency may be in the process of development, an agency of wide usage in industry. It is known the certain chemical reactions will take place under unusual conditions of temperature and pressure when stimulated by supersonic vibrations. The sterilizing properties of high frequency vibrations are also under investigation.

▶ **WHOA!** . . . Reliable records show that tube manufacturers during the year 1935 brought out 99 new types of receiving tubes not available before that year. Thus the tube designers keep up their good (sic) work of confusing engineer, trade and consumer with new varieties of vacuum tubes before the possibilities of those already existing have been digested.

All we need now is a whole new batch of deflection type tubes and a whole new batch of secondary emission tubes.

▶ **A.F.C. FOR AUTO RADIO** . . . It seems to us that a most logical place for automatic tuning systems, made possible by the automatic frequency control circuits, is in auto radios. Much too much effort must now be expended by the driver of a car to tune in the desired station, taking his attention from the vital business of keeping his engine of destruction on the road and out of the rear of someone else's car. This would be much better than trying to devise better tuning indicators for auto radio, for which there is much demand at the moment. Unless radio people make the auto radio safe, there is strong likelihood that safety programs may have too much to say about radio for radio's own good.

P.S. . . . The RMA and SAE Committee on Automotive Radio at a recent meeting condemned the use of visual tuning indicators on auto radios.

Recording by Ultra-Violet Light

In variable width recording, improvement has been secured by using filtered light with an optical peak at 3800 Angstrom units. Exposures made by short wave length light are restricted to the emulsion surface, reducing halation from the film base, limiting image spreading. The chromatic correction of lenses is better with a relatively narrow band of wave lengths. Diffraction of the recording beam, which limits definition, is less with short wave length filtered light. As a result image resolution and sharpness are greatly improved. Under the microscope, a 9000 cycle track made with filtered light looks as good as a 3000 cycle track made with white light. To take full advantage of this improvement a non-slip printer has been evolved with a regularity of motion equivalent to that of a recorder. In it filtered light is used for illumination. This development is due to Glenn L. Dimmick of RCA Photophone.

Progress in Sound Pictures

Volume range expansion—wider frequency range—automatic rerecording—new playback technique—better film motion—u-v recording—new theater reproducers

By CARL DREHER
RKO Studios
Hollywood, California

DURING the somewhat turbulent honeymoon which followed the union of motion pictures and sound recording, the objectives of the sound technicians were very limited. Under the existing conditions, the technique was confined to one, two, or three people standing stock-still, delivering lines with more trepidation than expressiveness to a stationary microphone suspended just out of the camera field. The idea that the microphone might be moved during a take was regarded with horror. Shifting the camera was downright impossible, because it was housed with the camera men in a tremendous padded cell, which, while it kept the noise of the camera out of the microphone, made an even louder noise of its own whenever it was moved.

With the advent of sound, accordingly, motion pictures became practically a series of still photographs. The duty of the sound man was to get an accompanying record as loud and intelligible as possible, whether he was recording a long, medium, or close shot. The nature of the sound had little relation to the picture.

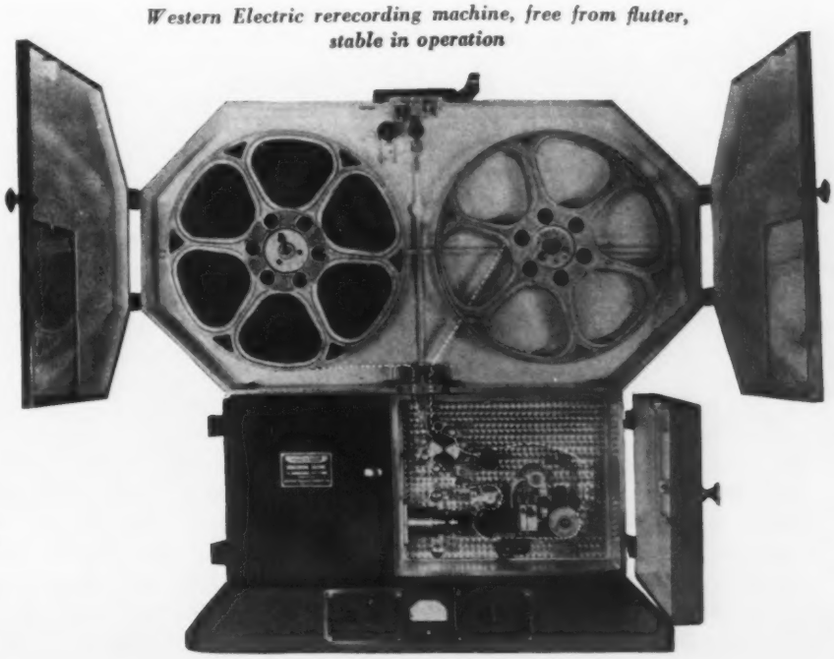
This technique did not give satisfaction very long. The sound technician, sometimes spontaneously, and sometimes with a little urging from directors and others, began to record "in perspective." A long shot track not only had more reverberation than a closeup, but the volume was allowed to drop proportionately. Then mobility was reinstated. The idea of the microphone boom was old; improved forms, first of wood and later of steel and aluminum, were devised to swing the microphone over any part of the set to follow the action. At the same time camera blimps were developed, and photographic flexibility was gradually restored.

At about the same time the possibilities of rerecording began to be probed. At first only those sounds reached the film which the microphone could pick up on the set. But now it proved possible to take an original sound track, run it through a reproducer, convert it back into the corresponding electrical currents, and mix it with other audio currents derived from a new microphone pickup or other sound tracks. At first only two tracks could be mixed, and that with difficulty. In time it became possible to mix any number of tracks within reason. The ultimate result was that many scenes were shot silent, and the necessary sound effects were dubbed in during the editing stages of the picture.

While the wonder of synchronizing sound and picture was new, no one minded a certain amount of background noise generated by dirt in the track. Soon, however, people began to realize that this annoyance could be reduced, if not altogether eliminated. To accomplish this the light transmission of the recording equipment was limited to the amount necessary to carry the modulation. In the case of variable width tracks, instead of leaving half the track area clear during periods of modulation, a movable mask was added to shut off all but a narrow marginal area. In variable density recording, the light valve was modified to shut off as much illumination as possible for any given amplitude of recording. In either case the action was automatically controlled by diversion of part of the recorder input and subsequent rectification, so that the envelope of the modulation controlled the admittance of light, with a resulting reduction in the surface noise of the film.

The next step was to increase the frequency range through improvements in amplifiers and loud speakers. Frequently this was done

Western Electric rerecording machine, free from flutter, stable in operation



Two views of the RCA mixer console. Has a 4 position mixer with individual frequency compensation. A neon volume indicator provides visual warning against overloading

The close-up of the mixer console showing ease of access for repair. The neon bulbs may be seen on the underside of the hinged panel

with more enthusiasm than skill, and the result in many theaters was an over-bassing of the product which made human footfalls sound like the tread of an elephant. This was typical of the lack of correlation between reproducer and recorder engineering. Much still remains to be done in standardization of recording and reproducing characteristics.

Music Recording

At first music was recorded on the same stages as dialogue. To keep dialogue reverberation within permissible limits, stages had been lined with large quantities of rockwool or other absorbents, so that a stage, say, 400,000 cu.ft. in volume, had a reverberation period, at 512 cycles, of only about 0.75 second. This was a suitable value for dialogue, but music recorded under these conditions lacked brilliancy and loudness.

In the last two years music stages have been subjected to a process of deabsorption. Usually one end of the stage, where the microphones are located, is left dead, while the other end, where the musicians sit, contains large quantities of wood or other sound-reflecting material. Sometimes the wood is fastened to the walls, or it may be placed around the orchestra in the form of large flats. In either case it is found advisable to avoid parallel surfaces by "splaying." Instead of forming a plane surface, the wood is set at slight angles. An equivalent method is to harden two adjacent walls of a stage, and set up the orchestra between them, with the microphones on a diagonal. Increasing the reverberation time to between 1.5 and 3.5 seconds by these methods results in re-inforcing of the higher notes by reflection, and the lower tones by resonance in the panelling, increasing the brightness and apparent loudness of the instruments.[1] The studio is the only feasible place for adding reverberation to music; the theatre must be left relatively dead for the sake of dialogue intelligibility.

Playback Technique

Over three years ago it became apparent that the best results in recording certain types of music could be secured only by separating photography and sound recording. Many vocalists emit beautiful tones at the expense of facial contortions which, in a head closeup, would inspire despair or derision in audiences. The remedy is not to photograph them while they are singing, and not to let them sing while they are being photographed. In the playback or pre-scoring method, one first makes a voice track, with or without orchestral accompaniment, just as it would be done in a phonograph recording studio (A). This track is then played back through a reproducer, and the artist pretends to sing, or actually sings *sotto voce*, taking care to look as pleasant as possible while the picture is taken (B). Under these conditions, the release print is a strictly synthetic product—but much more entertaining than if it had been made in a more primitive manner.

The first playbacks used either film or wax disc recording. A more re-

cent development employs cellulose or metal discs, obviating the delay and expense of processing from film or wax.[2] Cellulose acetate, or any of a variety of similar disc materials, affords immediate playback, in the studio or on location, at a very moderate cost. The technique is the same as in broadcast "air checks."

The same method is used in judging orchestra balance. The conductor rehearses the orchestra and listens immediately to the playback before making a take. After one learns to compensate for the difference in frequency characteristics, it is possible to get a surprisingly accurate idea of how the take will sound on film, and a considerable amount of costly guesswork is eliminated.

When a number of tracks are combined into a composite sound negative by rerecording, conflict usually occurs. The music director often complains that the music should be louder, while the sound man who recorded the dialogue feels otherwise. To minimize such disputes, William Mueller has devised a method whereby the dialogue automatically depresses the level of sound effects and music to the extent required to preserve intelligibility.[3] An amplifier bridged across the output of the dialogue reproducer feeds a rectifier, the d-c output of which varies the gain of the effects or music amplifier by altering the grid bias of a variable-mu tube. As soon as the dialogue stops, the music or sound effects are returned to a higher level without noticeable delay.

Volume range and noise suppression are merely different phases of the same subject, since the ground noise level in film recording determines the permissible signal limit on the low side, while undistorted amplifier output capacity in theatres determines it on the high side. Before anti-ground noise methods were introduced, the volume range on film was about 30 db. A symphony orchestra, however, has a volume range of about 70 db. Ground noise reduction gave an additional "lift" of about 10 db, so that the effective range rose to the neighborhood of 40 db. Under these conditions, normal dialogue level is set at about 10 db below 100% modulation, affording a 10 db rise for loud dialogue, musical crescendoes, noise effects, etc.

Some years ago Douglas Shearer evolved the "squeeze track" method for increasing volume range with variable density recording. For average dialogue he utilized only half the width of the track, masking out the other half. For full volume range the mask was withdrawn and the whole track utilized, affording a 6 db extension of volume range. However, as halving the track reduced the surface noise only 3 db, the net gain was only 3 db.

By increasing the transmission of a variable density track in printing, it is possible to raise the volume 6 db before serious distortion is encountered. This method was used in the recording of Columbia's *One Night of Love*, a picture which attracted attention through its wide volume range on Grace Moore's voice and the orchestra recording.

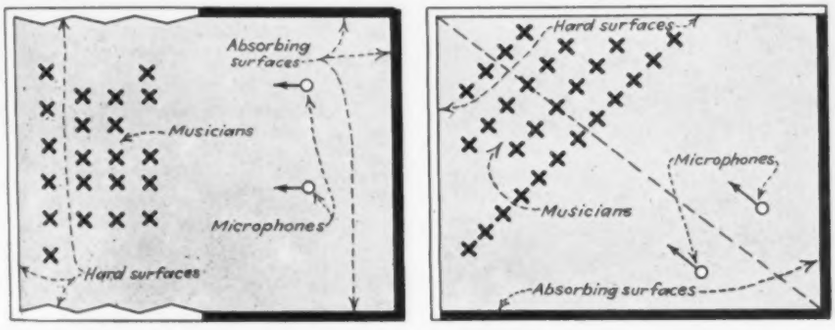


Fig. 1—Left—Music stage with splayed reflecting surfaces on sides. Right—Newer arrangement showing adjacent walls with reflecting material and a diagonal set-up

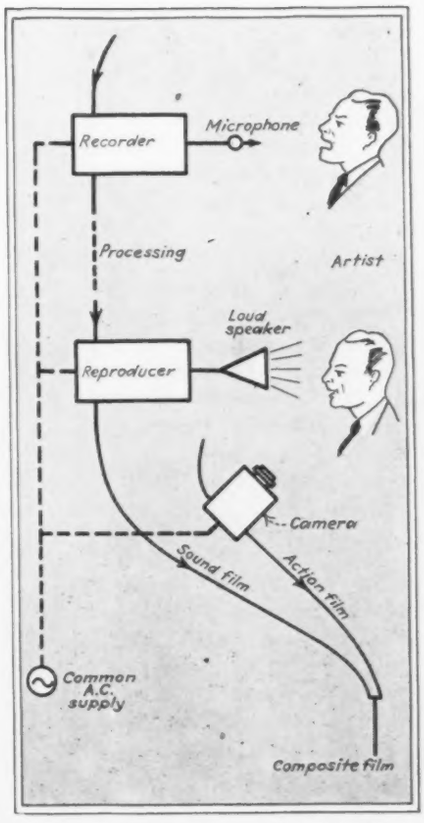


Fig. 2—First the recording of the song (in a studio especially prepared); then the recording of the action to the accompaniment of the song played back; and then the combination of the two into a composite film

Nathan Levinson has recently described a method of volume range expansion which utilizes the combination of variable density and variable width recording.[4] Variable density recording is used for average volume sequences, as for conversational dialogue, and variable width recording for high volume sequences. Since an unmodulated variable width track, half opaque and half transparent, has a transmission of 50%, as against 20% for unmodulated variable density recording, for a given percentage of modulation the variable width track reproduces at a level about 8 db higher than the variable density track. By combining this gain with the "squeeze track" method, a total extension of 11 db in volume range is avail-

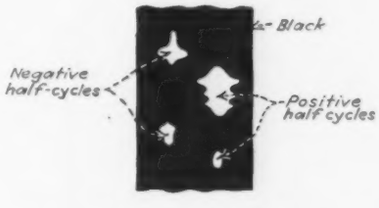


Fig. 3—RCA double sound track

able—if the theatre reproducer has adequate output capacity. Thus the volume range is raised to about 50 db.

RCA Photophone has developed a push-pull track which is inherently noiseless, in that the only transparent portions of the track are those carrying modulations. This track has a volume range of 55 db, and dispenses with anti-ground noise equipment in the studios. At present only a few theatres are equipped for push-pull reproduction. At present it is necessary to rerecord onto standard track for release, but, even so, an improvement in noise reduction and quality is realized.

Improvements in Film Motion

Serious distortion is also caused by even small speed changes in recording and reproduction. Such speed changes result in various types of spurious frequency modulation. The frequency of the signal periodically swings above and below the correct frequency, resulting in the generation of unwanted side-bands of various frequencies. "Flutter" is defined as the distortion caused by frequency modulation. The most common forms are a slow drift, known as "wows," which gives a whining character to musical notes, and a higher frequency distortion at 96 cycles, caused by the sprocket holes in the film (four sprockets per frame, multiplied by 24 frames per second). The latter is known as sprocket-hole modulation, and it imparts a wheezy, raspy quality to certain musical notes, somewhat similar to the effect of non-linear distortion. Recent investigations on flutter distortion have reduced the problem to a quantitative basis. [5, 6]

In general, drum-type reproducers are more susceptible to low frequency variation, while gate-type reproducers give more trouble with sprocket frequency modulation and other higher pitched irregularities. Often both types occur together. The seriousness of the resulting distortion depends on the nature of the recorded material, the reverberation in the space where reproduction takes place, and subjective factors in the listener. Usually speech is not much affected, but certain types of music may be terribly distorted. Moreover, the effect is cumulative, so that flutter in recording is added to the flutter in rerecording, and the sum of these, photographed on the film, is added to the flutter in reproduction.

Quantitatively, flutter is of a low order. Thus, in a reproducer, a flutter of 0.1% is allowable and considered very good, 0.4-0.5% is average in present-day theatre installations, and 1.0% or worse is quite common. Even 1% flutter may not distort dialogue seriously, but what it can do to a coloratura soprano voice is beyond belief, unless one has heard it. During 1935 this difficulty was encountered with the voices of Jeanette MacDonald in MGM's *Naughty Marietta*, and with Lily Pons, to an even worse degree, in RKO's *I Dream Too Much*. Miss Pons, in particular, emits pure tones, almost free from harmonics, which, viewed on film, look as if they had been made with an oscillator.

Theatre Reproducers

Improvements in recording naturally call for concommitant improvements in reproduction.[7] Shearer and Hilliard lay down the following specifications for a modern system:

(1) The frequency characteristic is to be flat within 2 db between 50 and 8000 cycles over the entire angle of distribution within 10 feet of the mouth of the loud speaker.

(2) To avoid excessive amplifier sizes, the electro-acoustic efficiency of the loud speaker is to be nearly 50%.

(3) A volume range of 55-60 db is required.

(4) The amplified capacity is to be not less than one acoustic watt per 1,000 sq.ft. of floor area, with the auditorium adjusted to optimum reverberation time.

(5) Sound head flutter is not to be greater than 0.1%.

They do not recommend reproduction above 8,000 cycles with a lower-cut-off of 50 cycles. To cover an adequate frequency range, three sets of loud speakers were installed in many theatres: low frequency cones operating up to about 300 cycles; middle range horns for the 300-3,000 cycle band, and small high frequency exponential horns emitting from 3,000 cycles up. Dividing networks separated the frequency ranges in the output of the amplifier, but since these networks could not be of the sharp cut-off type, some overlapping was experienced.

Shearer has reduced the horn types to two, with a dividing frequency at 250 cycles. The dividing network has a fairly rapid attenuation (12 db per octave), which keeps the low frequency energy in the high frequency units below an allowable value.

Trouble has been experienced in many theatre installations by reason of the few high frequency exponential horns radiating in a narrow beam, within which reproduction was excessively sharp, and outside of which reproduction sounded dull. This caused many futile arguments following previews, the underlying difficulty being that the disputants had been listening to different kinds of sound in various parts of the house. Harvey Fletcher of the Bell Telephone laboratories devised a multiple exponential horn which sprays high frequency sound all over the theatre. By using 16 or more horns stacked in a single unit, no part of the house is left without its quota of high frequency sound. The Shearer high frequency horn is of this type. It is fed through a Y-throat by two dynamic driving units, so that in the event of failure of one unit, the high frequency output of the system is not entirely interrupted.

The low frequency speaker is a large folded exponential horn, driven by four 15-inch cones connected in series parallel, thus again affording breakdown protection. The high frequency horn is normally mounted on the low frequency horn. (See page 24, March *Electronics*.)

With current improvements in apparatus design, and the training of recording personnel in showmanship, there is every reason to expect further improvements in the naturalness and dramatic effect of sound with motion pictures.

[1]Bagenal and Wood: "Planning for Good Acoustics." London, 1931.

[2]G. M. Best: "Improvements in Playback Disc Recording." *Journal of the SMPE*, August, 1935.

[3]W. A. Mueller: "A Device for Automatically Controlling the Balance Between Rerecording Sounds." *Journal of the SMPE*, July, 1935.

[4]Nathan Levinson: "A New Method of Increasing the Volume Range of Talking Motion Pictures." *Journal of the SMPE*, February, 1936.

[5]E. D. Cook: "The Technical Aspects of the High-Fidelity Reproducer." *Journal of the SMPE*, October, 1935.

[6]T. E. Shea, W. A. MacNair and V. Subrizi: "Flutter in Sound Records." *Journal of the SMPE*, November, 1935.

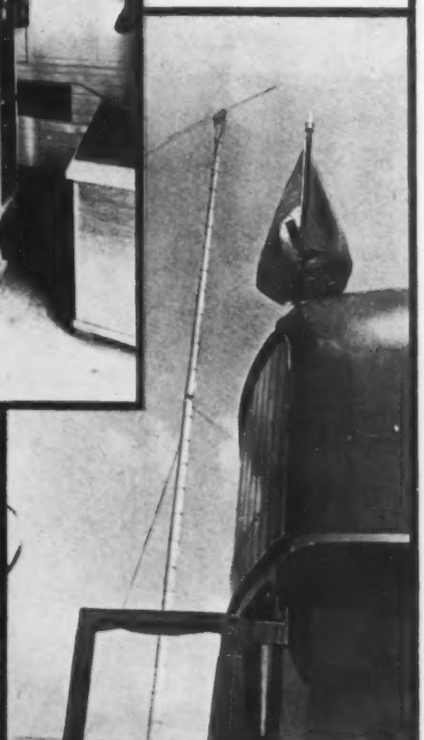
[7]John Hilliard: "A Study of Theatre Loud Speakers and the Resultant Development of the Shearer Two-Way Horn System." Academy Research Council Bulletin, March, 1936; *Electronics*, March, 1936.

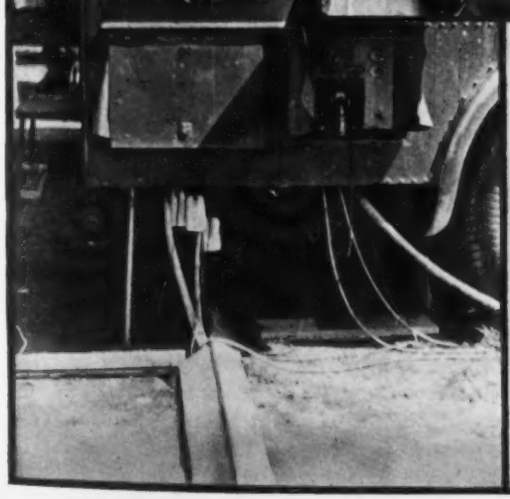
TELEVISION ON WHEELS

The transmitting equipment occupies 14 trucks, the crew and accessory apparatus, six

Lower left; film scanning truck, showing film projector and disc scanner in foreground, cathode-ray monitor in panel at rear

Below, the horizontal quarter-wave di-pole antenna which radiates seven meter signals from the transmitter truck





The truck (above) contains fireproof safes for storing film, a reel of which is under repair on the table

Output coaxial cables of the scanning truck, which connect the television pre-amplifier to the input stages of the two 10-kw transmitters

THIS $900,000 television caravan is traveling about in Germany, finding the best locations for u-h-f transmitters and giving demonstrations to local audiences. Two 10-kw transmitters for sight and one for sound, requiring a crew of thirty men, supply 180-line, 25-frame pictures from talkie film, prepared by the office of the Minister of Propaganda and Enlightenment.

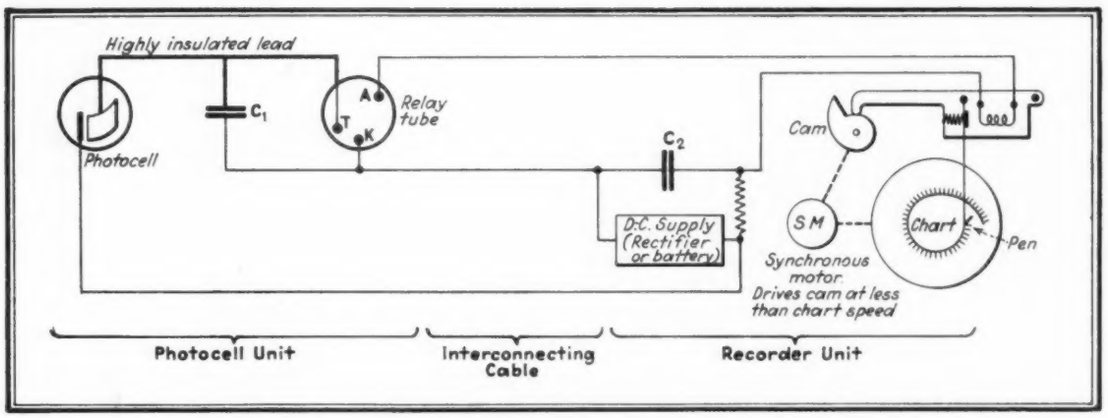


Fig. 1—Fundamental circuit of the u-v recording meter

An Ultra-violet Recording Meter

By L. J. WOLF

*National Broadcasting Company**

Fig. 2—Relay tube, WL-759. In practice it is coated with ceresin wax containing a black dye to improve the electrical insulation and prevent light from striking the electrodes. The trigger electrode is connected to the top cap. Anode and cathode connections are through the base pins

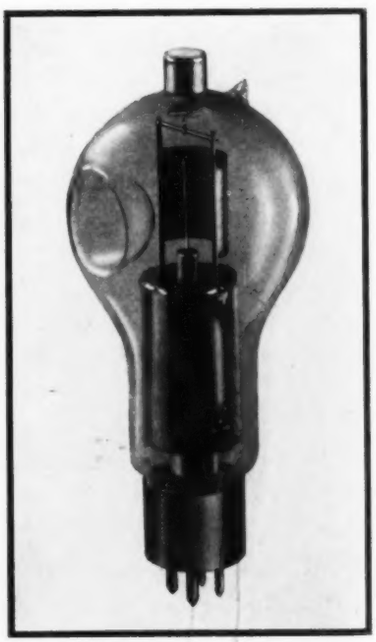


Fig. 3—Tungsten cathode phototube. Light having a wavelength longer than lower cut-off of the tube enters through the drawn-in window shaped to improve the transmission quality. Shorter wavelength radiation causes the half-cylindrical cathode to emit electrons collected by the anode rod

THERE are only a few specific remedies for diseases known today. Sunlight is an important one of these because of its vitamin-D producing ability. A deficiency of vitamin-D in the diet causes rickets, a nutritional disease that deforms so many of the city-bred children. In some industrial centers more than half of the children suffer from rickets.[1, 2] Even maternal mortality can be traced to rickets in most cases;[3] and the maternal mortality rate in the United States is the highest in the civilized world.

With our smoky cities and our sedentary habits which keep us indoors, an artificial supply of vitamin-D is desirable for adults and necessary for growing children. This may be either in the form of medicines prescribed by physicians (cod-liver oil, egosterol, etc.) or exposure to ultra-volet light; or through a mass-preventitive of rickets such as a universal food to which vitamin-D can be artificially added. As such, irradiated milk is therefore finding an ever increasing sale; in many cities a large part of the milk sold is artificially supplied with vitamin-D. In addition, irradiated milk is thought to be the cheapest method of providing antirachitic food.

The formation of vitamin-D is probably a photo-chemical reaction. In other words, the reactions are brought about by the absorbed radiant energy. Evidence shows that vitamin-D is evinced in some substances such as milk by exposure to light of the required intensity having a wavelength range from 2,700 to 3,200 angstroms, while some evidence shows that wavelengths less than 2,700 angstroms tend to destroy it.

A liquid which can contain vitamin-D is readily irradiated when passed over a vertical plane surface in a thin film in front of an artificial source of ultra-violet light. Open arc lamps using carbons especially

designed for ultra-violet intensity, and enclosed mercury arcs of various types are used for this purpose. The artificial methods of irradiation to produce ultra-violet light have the advantage over natural methods of sources in that the dosage can be accurately determined and measured. Heretofore, however, this measuring method had been laborious and slow because biological results have been used almost exclusively. Any of the usual methods of measuring light strength such as ordinary photocells, photometers, etc., on the light source are of little value in measuring vitamin-D for commercial production. The biological assay method entailed the maintenance of a group of white rats for test purposes. A test group of animals would be fed samples of the irradiated substance, for a given period, after which time inspection of the bones at dissection would indicate the efficiency of the irradiation process. In the meantime, of course, the irradiated product had been passed on to consumers.

A need has existed therefore for a meter which is rugged enough to be applicable to commercial practice and at the same time sensitive enough to record the intensity of very small sections of the ultra-violet spectrum.

Meters have been made[4] for laboratory use, but these have not been specifically constructed to give permanent records and to stand the rigors of commercial operation in humid atmospheres and by personnel unskilled in the operation of such devices.

Recording meters are available which utilize some form of cell which transforms light into electrical energy. Such cells, however, respond to light of almost any wavelength and thus require filters to narrow the response band. Filters which would narrow the response band the desired amount would make the cell too insensitive to be of practical use.

A type of meter is now in use[5] which has recently been developed by Westinghouse to give continuous direct indications of the ultra-violet intensity in any band of wavelengths. This meter is applicable to commercial installations. The meter consists essentially of a photocell which is sensitive in the desired range, and a recording mechanism operating without any sort of amplifier.

The Photocell

In order to build a photocell sensitive only in the ultra-violet regions[6] advantage is taken of the variations in absorbtion of the glass envelop, and of the variation with wavelength in photo-electric emission from different metals. The various materials for making envelops pass the longer waves but cut off at or near the ultra-violet region. Certain metals can be chosen, the photo-electric emission of which is inappreciable in the longer waves and approaches a maximum at or near the ultra-violet region. Therefore, by a proper choice of envelop material and emissive material, a photocell will result which passes only a predetermined wave band. Since the band of wavelengths passed by the photocell is limited by inherent properties of the materials used, there is no chance for aging effects or differences in manufacture to change the band. Different cells may show different orders of sensitivity but the shapes of the sensitivity curves are unchanging.

Trigger Tube and Recorder Circuit

In order to utilize the extremely minute photo-electric currents with-

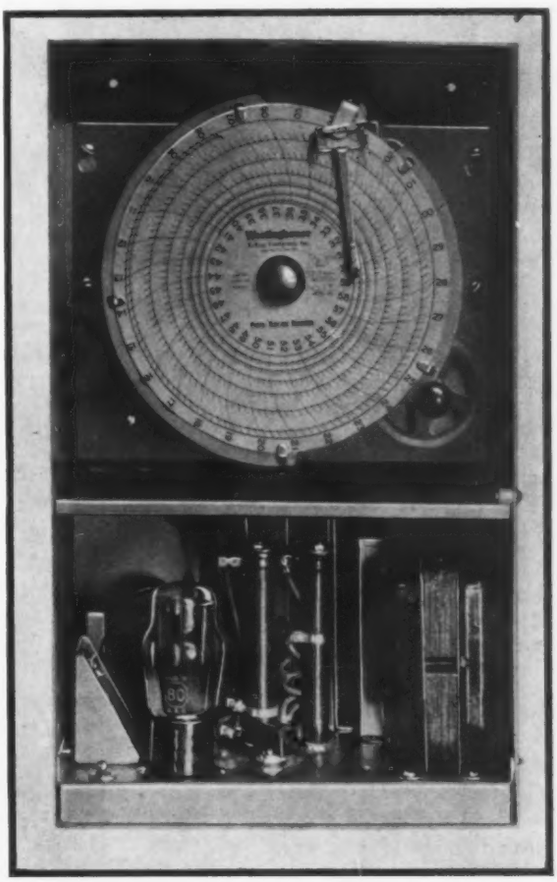


Fig. 4—The recorder. This unit contains both chart mechanism and power supply. The light intensity for the first part of the chart shown (outer spirals) was such that approximately 4 marks per minute were registered. Later the intensity was doubled producing 8 marks

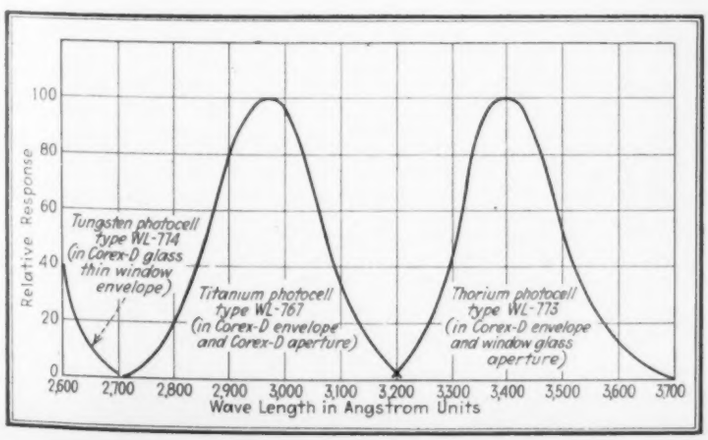
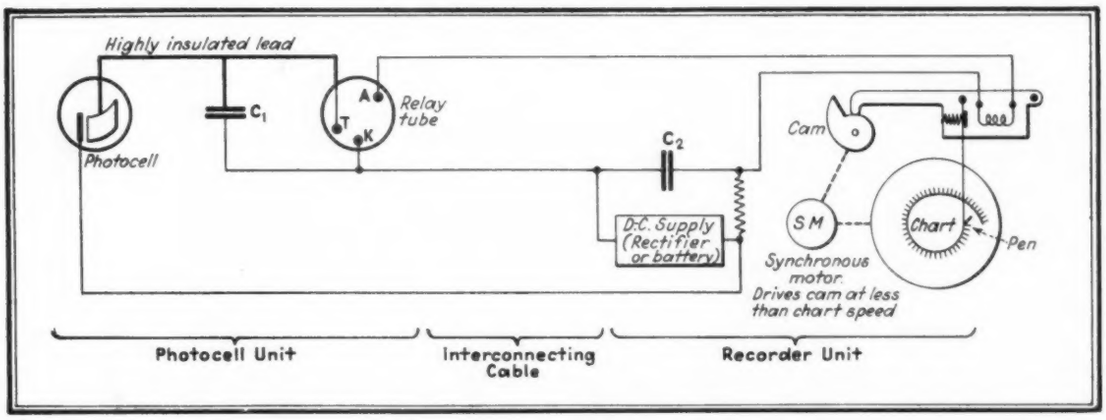


Fig. 5—Admission characteristics of phototubes as a function of surface and window



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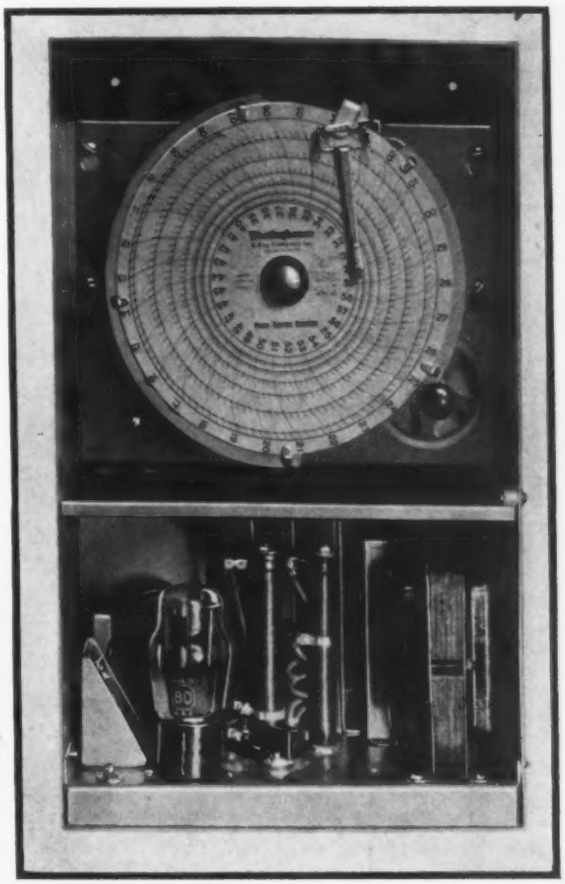

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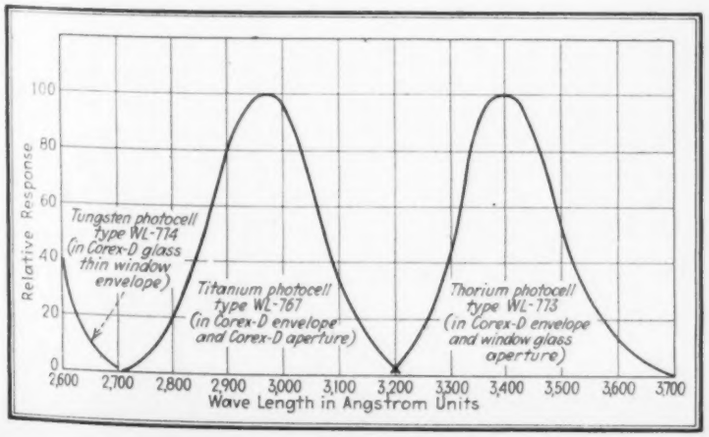

Fig. 5—Admission characteristics of phototubes as a function of surface and window

out resort to d-c amplifiers with the attendant necessity for calibration and frequent rechecking, a relay tube is used. This consists of a vacuum tube containing three solid electrodes spaced a few millimeters apart in an atmosphere of inert gas. The three electrodes act as anode, cathode, and trigger electrode respectively. The current from the photocell charges the condenser C_1 at a rate proportionate to the intensity of the ultra-violet light striking the cell. The voltage across the condenser, therefore, rises to a value which is the breakdown voltage of the elements *T* and *K* of the relay tube. When the breakdown occurs, the arc strikes to the anode through which a considerable amount of power can be handled. When the condensers C_1 and C_2 are discharged the arcs must stop, hence the cycle of operation can repeat. In this manner the relay tube enables the feeble photocell current to control enough energy to actuate a recorder mechanism.

The recorder consists of a pen movement *M* with a pen bearing on a chart. The position of the pen is determined by a cam. A synchronous motor *SM* revolves the chart and also turns the cam at a rate slower than that of the chart. A spiral line is, therefore, drawn on the chart as it revolves.

When anode current flows through the relay tube due to action of the photocell, the condenser C_2 discharges through the pen magnet coil. Hence a deflection of the pen will occur. This deflection acts for only an instant because C_2 discharges rapidly.

The direct current source is a conventional rectifier or can be a battery. Very little current is required as the charging current for C_2 is of the order of two or three milliamperes intermittently and the photocell current is very much less than this.

The sensitivity of the meter is dependent on the time required by the current flowing through the photocell to charge the condenser. The frequency with which the deflections of the pen occur is, therefore, proportional to the capacity of the condenser C_1. Thus calibration of the meter is readily altered as desired by changing C_1. The constancy of calibration is dependent on the pertinent properties of the photocell, the condenser and the relay tube. The photocell is not subject to aging defects since it operates with a high vacuum and no internal deterioration takes place. The condensers used are of the moulded mica type and are selected and treated for low leakage conductivity. The relay tube, although operating with a gaseous atmosphere, passes currents of a low order of magnitude only, so no bad effects occur such as those due to clean-up. Experience with these relay tubes over a period of several years fails to show any change in calibration of a tube properly seasoned.

When used to measure milk irradiation, the ultra-violet meter is so mounted that the photocell is about 24 inches from the arc lamp, with the photocell pointing directly at the arc, and in the horizontal plane of the arc. The photocell unit is positioned so that it intercepts some of the light passing to the milk and consequently will measure the actual irradiation, as the flow conditions are kept constant.

The recorder unit is mounted at any distance from the photocell, since the lead wires have nothing to do with calibration. The charts are kept as a record and are available to the government milk inspection services in the same manner that recording thermometer charts are available as records of pasteurization.

Calibration

The unit of ultra violet radiation has not yet been standardized and no constant and predictable source of radiation has been developed; hence the calibration of an ultra-violet meter must be empirical and depend on results already known. The ultimate unit of radiation is the quantum, therefore the calibration could be in terms of quanta per second per unit of area. Since the quantum is so small the erg (1,325 $\times 10^8$ quanta) is a more convenient term. Inasmuch as one microwatt is equivalent to 10 ergs per second the watt would also be convenient to use.

When either of the units mentioned above (ergs/sec./sq.cm. or microwatts/sq.cm.) is used, the meter becomes a primary standard because the readings refer back to the fundamental unit, the quantum. When the meter is checked back only against biological assays it becomes, in effect, a secondary standard.

In practice we are less interested in the absolute calibration than in an arbitrary unit suited to the particular need. For instance, the light from incandescent lamps is generally measured in lumens rather than quanta; so the calibration of the ultra-violet meter is expressed in vitamin-D potency units for convenience.

General Utilization

Although these meters have been principally used in the commercial irradiation of fluid milk other uses have been suggested and placed in practice.

In the perfection of methods for irradiating milk the maintenance of proper and uniform thickness of the flowing film is necessary. It has been determined that the ultra-violet recording meter, appropriately calibrated, is very sensitive in detecting variations in thickness of the milk film.[5]

In the study of the aging of mercury arc lamps, data on the variation with age of the output in various parts of the spectrum is easily obtained.

Studies of the variation of the ultra-violet region in the solar spectrum are being made in the tropics as an aid in medical research. An ultra-violet meter is equipped with a photocell sensitive in a desired range and kept pointed at the sun from forenoon until afternoon.

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*This paper was prepared by Mr. Wolf while at the Westinghouse X-Ray Corporation.

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[2]McCollum, E. V., and Simmonds, N. *The Newer Knowledge of Nutrition.* MacMillan Co., 1925.

[3]Wynne, Dr. Shirley W., Vitamin D Milks from the Health Officer's Standpoint. *Certified Milk.*, Oct., Nov., 1935.

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Practical Volume Compression

Details of an automatic volume compressor, designed for use in broadcast stations, which eliminates many of the troubles of previous designs and which has stood the test of actual use at WSFA for several months

By L. B. HALLMAN, Jr.
Broadcast Consultant
Montgomary, Alabama

PROBLEMS arising from the necessity of maintaining the audio voltages applied to the modulating units of broadcast transmitters within specified limits are as old as broadcasting itself. Below a given level the inherent noises of the system make high quality transmission impossible. Above a definite limit the transmitting units are overloaded. Improvements in equipment design, such as better tubes and more effective filtering in power supplies, have made possible a widening of the allowable volume range by extending the lower limit. Extending the upper limit does not, at present, seem likely. A volume range of 60 decibels can be accommodated in today's highest quality broadcasting systems. That this is inadequate is indicated by the fact that volume ranges of some 75 decibels must, at times, be accommodated. Also, the possible volume range of the average equipment in use today is 50 decibels, or less, rather than 60 decibels. The necessity for compressing extreme volume ranges to within the limits of the system is thus apparent.

This compression is usually accomplished manually and it is undoubtedly true that no substitute will be found for monitoring by an operator who has sufficient information at hand to enable him to anticipate volume peaks. The usual situation, however, is one wherein the operator cannot anticipate volume changes accurately and is usually forced to adjust the volume level after the first peak has passed. This often leads to erratic monitoring especially when a comparatively low volume level immediately follows a peak It has been found much better in such situations to compress the volume range automatically. Not only is the monitoring smoother, but the action is faster; that is, the reduction in gain commences immediately that the peak is encountered. Our purpose here is to describe such a unit that has been in use for several months and that has been tested under the most rigorous operating conditions. It introduces no distortion and has been found to provide a much smoother type of monitoring than is possible manually.

The characteristic operation of this unit is illustrated in Fig. 1. The linear relation between power input and output for a normal amplifier is illustrated by *AO*. That is, a volume input range *OP* produces a volume output range *PA*. Let us assume, however, that we cannot accommodate a volume range greater than *PB*. The compressor unit is adjusted to compress the natural range *PA* into the limit *PB* in the manner shown by the characteristic curve *OB*. It will be observed that there is a tapering off in rate of volume increase until the upper limit is reached where it remains constant. The unit has been designed to hold the volume constant over an additional increase in input of approximately 30 decibels without affecting the quality of the transmitted material.

In addition to its function in limiting the volume output range it will be observed that the characteristic shape of the compressed output versus input curve is such that the average voltage output can be increased without exceeding the permissible upper limit. Hence, the compressor can be used to increase the average percentage modulation of the transmitter output. By properly adjusting the point on the characteristic *OB* around which the average volume variation takes place this increase in average percentage modulation is accomplished without any appreciable effect on the normal artistic expression.

How Compression is Obtained

To understand more fully the operation of the compressor let us first consider a normal amplifier producing a linear relation between input and output voltage amplitudes, as illustrated by *OA* in Fig. 1. Assume the wave form of the input voltage to be given by the semi-periodic function $y = Ef(t)$. The purpose of the amplifier is, then, to change the

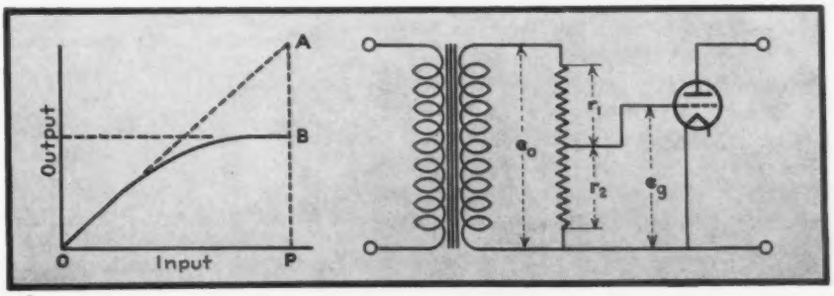


Fig. 1 (Left) Comparison of linear and non-linear power characteristics, showing the compressing action of the latter. Fig. 2 (Right) Fundamental volume control circuit

amplitude of the function without altering its basic form. That is, the amplifier output wave form may be represented as $y_o = AEf(t)$. It is the multiplying constant A, or amplification, that is altered when the gain of the amplifier is raised or lowered. Present broadcast practice is to alter A manually as required. Any device controlling A automatically must, of necessity depend on $Ef(t)$. For example, if the device is designed to reduce A automatically when the peak voltage exceeds a given value the time at which the device begins operating is determined by $Ef(t)$. The speed of operation of the control must be slow as compared with the period of $Ef(t)$, as otherwise the controlling device may alter $Ef(t)$ to an appreciable degree. The effect of the controlling device on A must also be determined by $Ef(t)$. Thus, it is clear that any device for automatically controlling the gain or amplification of an audio-frequency amplifier must depend on $Ef(t)$ for its operation. At the same time, the device must affect only A and not $Ef(t)$.

The compressor to be described here satisfies the above requirements. The principle of operation may be understood by referring first to Fig. 2. It is seen that,

$e_o/e_g = (r_1 + r_2)/r_2 = 1 + r_1/r_2$.

In manually operated volume controls, similarly connected, it is customary to keep $r_1 + r_2$ constant and vary e_o/e_g by varying r_1/r_2. The same result may be accomplished by holding r_2 constant and varying r_1 without regard to $r_1 + r_2$. This is accomplished by substituting for r_1 the plate or output circuit of a vacuum tube. The value of r_1 is then controlled by the voltage applied to the control grid of the tube whose plate circuit is connected at r_1. This d-c grid voltage is supplied by a rectifier and suitable filter. The rectifier input is determined by the voltage e_o.

A simplified schematic diagram of the complete unit is shown in Fig. 3. It consists essentially of two controlled stages. The two triode sections of V_3 are used to control the amplification of the two stages. The type 53 tube was found to be especially suited for use at V_3, since it could be used with zero fixed grid bias. Its high amplification factor is also advantageous. The tube, in this position, is somewhat microphonic, however, and it has been found desirable to mount it on sponge rubber.

FIG. 3. COMPLETE CIRCUIT DIAGRAM OF COMPRESSOR

T_1—500 to 750 ohm input transf.	C_7, C_8—8 μf (electrolytic)	R_4—3,500
T_2—Plate-to-grid transf., with plate side across R_6	C_{10}, C_{12}—6 μf (paper) C_{11}—3 μf (paper)	R_9—2,000
T_3—Plate to 500 ohm output	C_9—0.1 μf (paper)	R_{10}—50,000
T_4—Plate to grid transf.	S—S D.p.d.t. switch.	R_5—250,000
L_1, L_2—100 henry, 15 ma.	V_1, V_2—type 57	R_{12}—50,000
L_3, L_4—400 henry, 2 ma.	V_3—type 53	R_{13}—1.0 meg.
L_5—10 henry, 2 ma.	V_4—type 56	R_{14}—25,000 pot.
C_1, C_{13}—0.25 μf 350 v. (paper)	R_1—750; R_6—10,000	R_{11}—400,000
C_2, C_6—0.1 μf (paper)	R_2, R_7—50,000	R_{16}—750,000 rheo.
C_4, C_5—12 μf (electrolytic)	R_8—500,000	R_{17}—750,000
C_3, C_{14}—1.0 μf (paper)	R_3—500,000 pot.	R_{15}—100,000 voltage div.

The "control voltage amplifier" is any amplifier of sufficient gain, say two stages, a 57 pentode followed by a 57 connected as a triode.

No Distortion Introduced

It will be observed that there is nothing in this arrangement that will in any way affect the quality or linearity of the system, at a given setting, so long as the plate circuits of the two triodes of V_3 act as pure resistances. This requirement is realized by keeping the signal a-c voltage developed across the plate circuit of both sections of V_3 small. That is, the operating region is maintained within the linear portion of the plate voltage—plate current characteristic curve.

To this end, as will be noted, the signal voltage applied to the control grid of V_1 is developed across a 750-ohm resistor, R_1. At the peak level of —10 db., at which the unit normally operates, the peak grid voltage is on the order of 1.2 volts. Assuming, as a rather extreme case, a volume increase of 30 db. above the normal peak value the peak voltage developed across R_1 will be 38 volts, 36.8 volts of which will, in effect, be developed across the plate resistance of the two sections of V_3. This excess power will be dissipated in the plate resistance of the two triode sections of V_3. It will be observed that even in this extreme case the voltage developed across the plate circuits is a rather small percentage of the applied 300 volts fixed plate potential. It has been found that the distortion is negligible at signal power increases of this order. The transformer T_2 is connected so that the plate resistor, R_9, 250M ohms in parallel to the high impedance pentode plate circuit of V_1, is matched to the 10M ohm load resistor, R_{10}, across which the voltage applied to the control grid of V_2 is developed. This is a step-down ratio of approxiately 5 to 1, which insures against developing of voltages of sufficient amplitude to cause distortion in the second section. From this it is clear that very little amplification is obtained with the unit. The primary purpose of the control, however, is to maintain the peak volume below a given value. Amplification is not necessary and often not desirable.

It should be noted that a control of this type, using series controlling

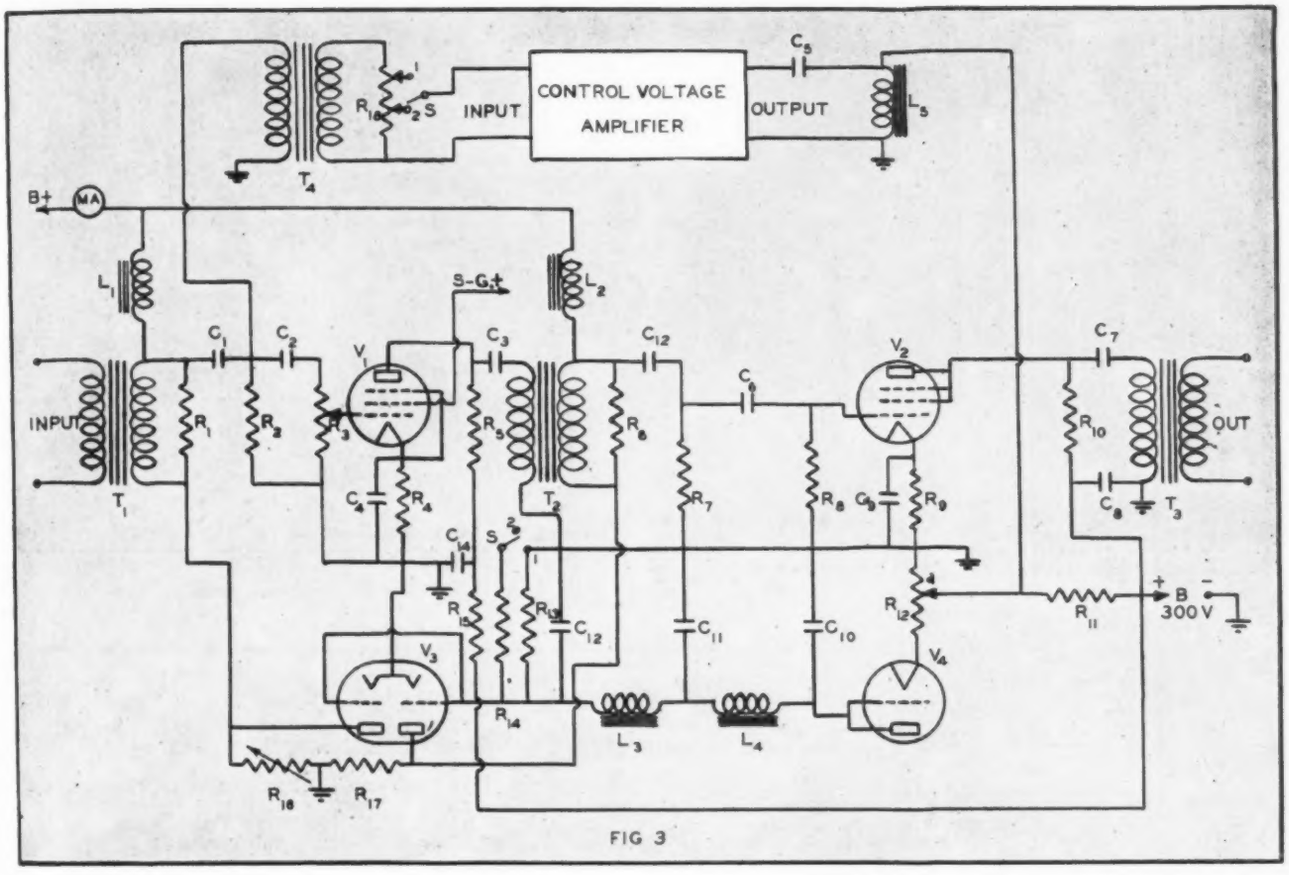


FIG 3

elements, is inherently free of distortion over wide volume ranges. That is, there is nothing introduced through the controlling element proper to produce distortion. Controlling units heretofore described have depended for their effectiveness on either the shunting action of the variable element, or the variation of potential of one of the grids of a multi-electrode tube. In either case the range of control possible, before objectionable distortion sets in, is usually insufficient. With the shunting control element this distortion becomes objectionable when the frequency characteristic of the transformer across which the shunting element operates is upset because of excessive impedance mismatch. The limitation of devices utilizing a variation of grid-potential is obvious. During intervals of high input-voltage swings the control grid will be swung outside the region of linearity between grid voltage and plate current.

With a control of the type described here the excessive signal voltage is developed across the controlling element and will not, therefore, introduce distortion so long as the variation is within the linear region of the plate voltage—plate current characteristic for this tube. Using a 53 or 6A6 with 300 volts on the plate a variation of + or — 60 volts is readily accommodated when the negative control bias has increased the effective plate resistance to approximately 150*M* ohms. This represents a total attenuation of 60 db. in the two sections of the unit, as described; providing a distortionless controlling range sufficient for the most extreme demands of practical operation.

Avoiding Cut-Off On Peaks

A problem encountered with a control of this type is the tendency to cut-off entirely at high input-signal levels. This, of course, is very objectionable. It is overcome in the unit described here by rendering the degree of control effective at the instant under consideration a function both of the degree of control and of the energy level passing through the system. This is accomplished by connecting the input transformer, T_4, of the control voltage amplifier, not directly across the signal voltage, but across the controlled input voltage to V_1. Thus the greater the degree of control effective the smaller the percentage of total signal voltage applied to the control voltage amplifier. The inherent tendency of the output voltage amplitude to pulsate on sustained tones is overcome by placing a high-pass filter (C_5, L_5) between the control voltage amplifier output and the rectifier, V_4, input. The cut-off frequencies of this high-pass filter and the low-pass filter (L_3, L_4, C_{10}, C_{11}, C_{12}) in the rectifier output are so adjusted that the pulsation is blocked out. The resistors R_{16} and R_{17} are also effective in stabilizing the unit, especially at high signal levels, where the effective plate resistance of the triode sections of V_3 becomes high.

The operation of the rectifier V_4 is of interest. It will be noted that the point "*a*," and rectifier cathode, is at a positive potential with respect to ground, the value of which depends on the ratio of the portion of R_{12} between "*a*" and ground and R_{11}. Before V_4 will become conductive it is

[*Continued on page 42*]

James Lamb, QST

Ed Jones, Broadcast News

J. H. Dellinger, B of S

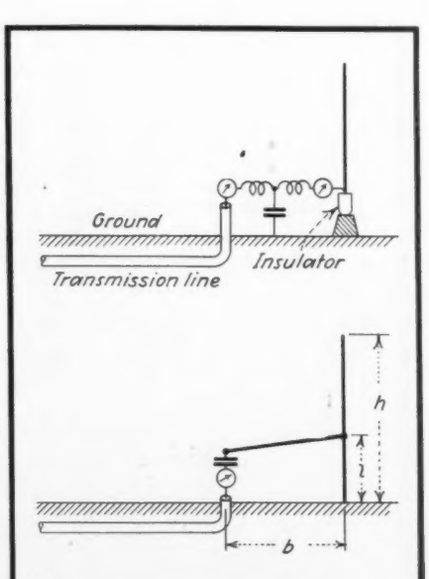
Wm. MacLeod, King Labs.

I. R. E. Annual

Six hundred engineers hear of new broadcast transmitting and antenna systems, and of automatic frequency control

PROMINENT among papers presented before the 600 engineers attending the annual convention of the I.R.E. at Cleveland, May 11, 12, and 13, were those relating to the generation of power at very high frequencies, and new circuits of importance to broadcast stations.

Particularly important was the contribution of William H. Doherty of the Bell Laboratories who has designed a high efficiency amplifier-modulator circuit which will effect considerable economies in the operation of broadiast stations, or other modulated transmitters. A 50 kilowatt station, for example, consuming normally about 235 kilowatts of power would require only 135 by the use of his system. Engineers in attendance at the convention estimated that a 500 kw. station, and there are several in the wind at the present time, would save about 1000 kw. of power by this method, soon to be a part of standard Western Electric transmitters.



Shunt-excited antenna of Morrison

In principle the Doherty system operates as follows: Suppose only a few tubes, or tubes of low power are in operation at low levels of modulation. Under these conditions these few tubes can be operated at fairly high efficiency, say 60 per cent. Then, as more power is required, by greater depths of modulation, other amplifier tubes are brought into play to supply this additional power. In such a manner a power output-efficiency curve would be much more uniform than in existing apparatus in which high efficiency is attained only at high modulation levels.

Imagine two tubes with their cathodes and plates in parallel and operating into a load *R*. Now imagine a network between the plate of one tube and this load *R*. This network acts like a quarter-wave transmission line in that its impedance measured at one end is inversely proportional to the impedance which is connected at the other end. Now for all values of grid excitation from zero up to the carrier level, this tube supplies all the power, the second tube being overbiased and having no plate current. The network presents to this power-supplying tube an impedance so high as to require this tube to operate at nearly its maximum possible r-f plate voltage swing in order to deliver the carrier power. The efficiency at the carrier output is correspondingly high, and may be from 60 to 70 per cent.

Now, unless something is allowed to happen, the current in *R* plotted against r-f grid excitation would slump off on still higher values of excitation. But in the Doherty system, the second tube now comes into action supplying power and effectively increasing the impedance in which the network is terminated. Because of the inverse characteristic of this network, this increase in impedance causes a *decrease* in load resistance to be presented to the first tube effectively increasing its r-f plate current without any increase in plate voltage. At complete modulation half the power is supplied by each tube.

In his paper, Mr. Doherty cited the case of a 50 kw. transmitter operating at 33 per cent efficiency. This

W. H. Doherty, Bell Labs.

R. H. Hackbusch, RMA Canada

C. T. Burke, General Radio

A. F. Murray, Philco

Convention

Generation of centimeter-wave power, high-frequency oscillograph, new uses for electron tubes are discussed

would require 150 kw. of which 100 kw. would have to be dissipated at the anodes. By this new system only 83 kilowatts would be required and hence the plate dissipation would be only 33 kilowatts permitting a saving in the water cooling system as well as in the power requirements.

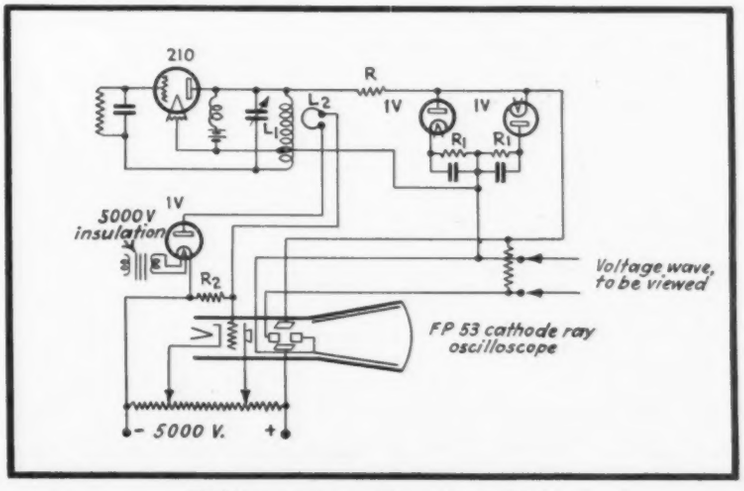
Annual power costs for large broadcast stations are such that savings of this nature may provide additional stimulus for new 500 kw. stations.

The Shunt-excited Antenna

Another development of interest to broadcast and other transmission engineers is the shunt excited antenna described by J. F. Morrison, also of the Bell Telephone Laboratories. This development leads to the abandonment of the tower or antenna base insulation. While this construction has been deemed necessary for the proper functioning of the antenna, it has introduced difficulties and complexities in both the electrical and mechanical features. Since insulating material is generally weaker mechanically than structural steel, the insertion of an insulator at the base of the antenna, where the mechanical forces are the greatest, has generally required a modification of what would otherwise have been the most economical design. The electrical complications introduced by the insulator, however, are of greater importance, and lead to greater additional expense and complication.

The impedance of the base-insulated antenna is in series with the coupling circuit which must therefore either be especially designed for each installation or provided with sufficiently liberal adjustment features to allow it to meet the wide range of antenna characteristics. With shunt excitation, the antenna impedance is divided into two parallel sections by the coupling connection. This allows considerable control of the equivalent antenna impedance by proper selection of the point connection, and thus greatly simplifies the coupling circuit. This method of excitation has no appreciable effect on the radiation characteristics of the antenna, but leads to a number of simplifications and economies.

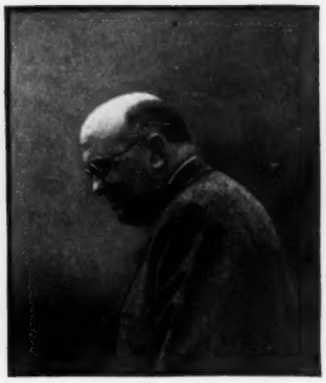
With the shunt-excited antenna a separate building for housing the coupling equipment becomes unnecessary, since the only equipment required is a single condenser. The circuit supplying antenna lighting is simplified to an even greater extent. Since the antenna is at ground potential at its base, filter circuits or coupling transformers are not re-



High-frequency oscillograph of Leeds

F. R. Lack, Bell Labs.

F. H. Shepard Jr., Radiotron; W. Richter, A. O. Smith



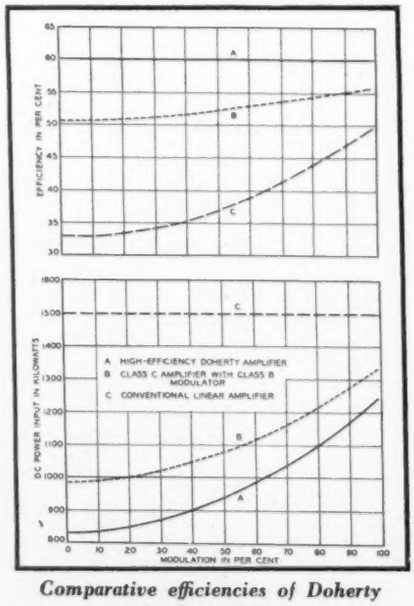
C. M. Jansky, Jansky & Bailey

quired. The circuit may be run directly to the base of the antenna and thence vertically up the structure. All forms of protection from lighting or other high voltages on the antenna structure also become unnecessary. With the base of the antenna at ground potential no precautionary measures need be taken either to eliminate high potentials or to keep people from coming in contact with the structure, and interruptions of the program due to lightning or static discharges are greatly decreased. Over and above these many advantages, the cost of the antenna itself is reduced. No base insulators are required, and the more rigid support made possible by a direct steel connection to the foundation permits the use of smaller cross-sectional dimensions.

Aural Compensation

Pointing out the characteristic of the human ear to demand greater inputs of power at low audio frequencies if they are to excite the same loudness response, and therefore citing the need for some form of aural compensation in phonograph reproducers and radio receivers, C. M. Sinnett of RCA Victor described several methods in use for volume and bass frequency expansion. One such system is used in Crosley receivers and consists of two incandescent lamps whose resistance varies with the current through them and therefore in a bridge circuit will permit more signal to get into the loud speaker system at high levels proportionately, than arrives there on low levels of input.

A second system consists of push-pull triodes having transformer coupling in both input and output circuits. The plate circuit which normally calls for a load of 20,000 ohms has the primary of its coupling transformer shunted on each side by a resistance of 500 ohms. A variable bias system dependent for its action upon the incoming signal is connected to the common grid return of the triodes. In this circuit, the effective transfer of energy is dependent upon the effective plate impedance of the tube and the resistance of the load. The tube impedance is dependent upon the grid bias and consequently with low bias there is a proportionally greater transfer of energy to the 500 ohm circuit than when high bias is used and the plate impedance of the tube increases. In this way, volume expansion is possible with relatively low distortion, the main disadvantage of the system as far as broadcast receivers are concerned being the greater cost over some other systems which do not employ transformer coupling.



Comparative efficiencies of Doherty and other amplifiers

K. W. Jarvis, Norwalk Eng.

A third system described by Mr. Sinnett has appeared under his signature in Electronics, November, 1935, and is in use in the RCA Victor D-22 receiver. His analysis of volume expansion as applied to a radio receiver is interesting. He stated that, "It will be found when expansion has been added to a radio set that new problems are confronted which were not present when phonograph records were used. Dance music, due to careful monitoring in the broadcast station, shows very little dynamic range; in fact, much less than on the average phonograph record. Symphony music becomes much more life like and with a variable amount of expansion, one can suit the music to his mood at that particular time. If we listen to a symphony program with maximum expansion it will be noted that as soon as the music stops, the noise level drops. When the announcer begins to speak, his voice is rather weak but builds up rapidly to a level roughly corresponding to that present during musical repro-

R. W. Gilbert, Weston

P. D. Zottu, Radiotron; Melville Eastham, General Radio

Rob't Leonard, Shallcross

H. L. Oleson, Weston

Geo. Lewis, I. T. & T., Ray Manson, Stromberg

The Editor-photographer

duction at high level. This particular effect can be partially overcome by increasing the time delay to the No. 3 grid of the expander tube. Having done this, we are faced with a rather unpleasant reaction to symphonic reproduction. Sudden crescendos are smoothed out and the effect the conductor desired is practically lost. For this reason, either a compromise must be assumed between voice and music or one must let voice take care of itself when the time delay has been adjusted for proper musical reproduction."

Dr. Dellinger of the Bureau of Standards reported on marked differences in the efficiency of transmission on the band between 500 and 1,300 kc. in the east-west direction as compared to the north-south direction. No reasonable explanation has been advanced to the present for this phenomenon. Further reports were made on the 54-day cycle already described in *Electronics* by Dr. Dellinger.

An ingenious use of phototubes and a d-c amplifier to provide a recording potentiometer was described by R. W. Gilbert of the Weston Electrical Instrument company. A variable indicating current is passed through a fixed resistor to oppose by its IR drop the unknown e.m.f. Unbalance currents are indicated on a mirror galvanometer which deflects a beam of light into one of two phototubes. The phototubes are in a bridge circuit connected to the grid-cathode path of an amplifier which exerts control over the indicating current. Upon a deflection of the galvanometer, this mechanism causes a readjustment of the indicating current to the proper value for potentiometric balance.

A useful extension of the art of using cathode ray tubes for investigating high frequency phenomena was reported by L. M. Leeds of the General Electric company. The apparatus he described is capable of tracing out a single cycle of a 30 megacycle wave. The waveform of a conventional oscillator is altered by means of a high vacuum rectifier circuit to obtain the necessary sweep.

Mr. Leeds pointed out that stray circuit capacities limited the dimensions of the sweep on the high frequencies. Thus the minimum capacity is of the order of 30 micro-microfarads which makes it impossible to get much above 30 megacycles in frequency. His solution is to operate the driving source at much lower frequency than the source of the waves to be studied.

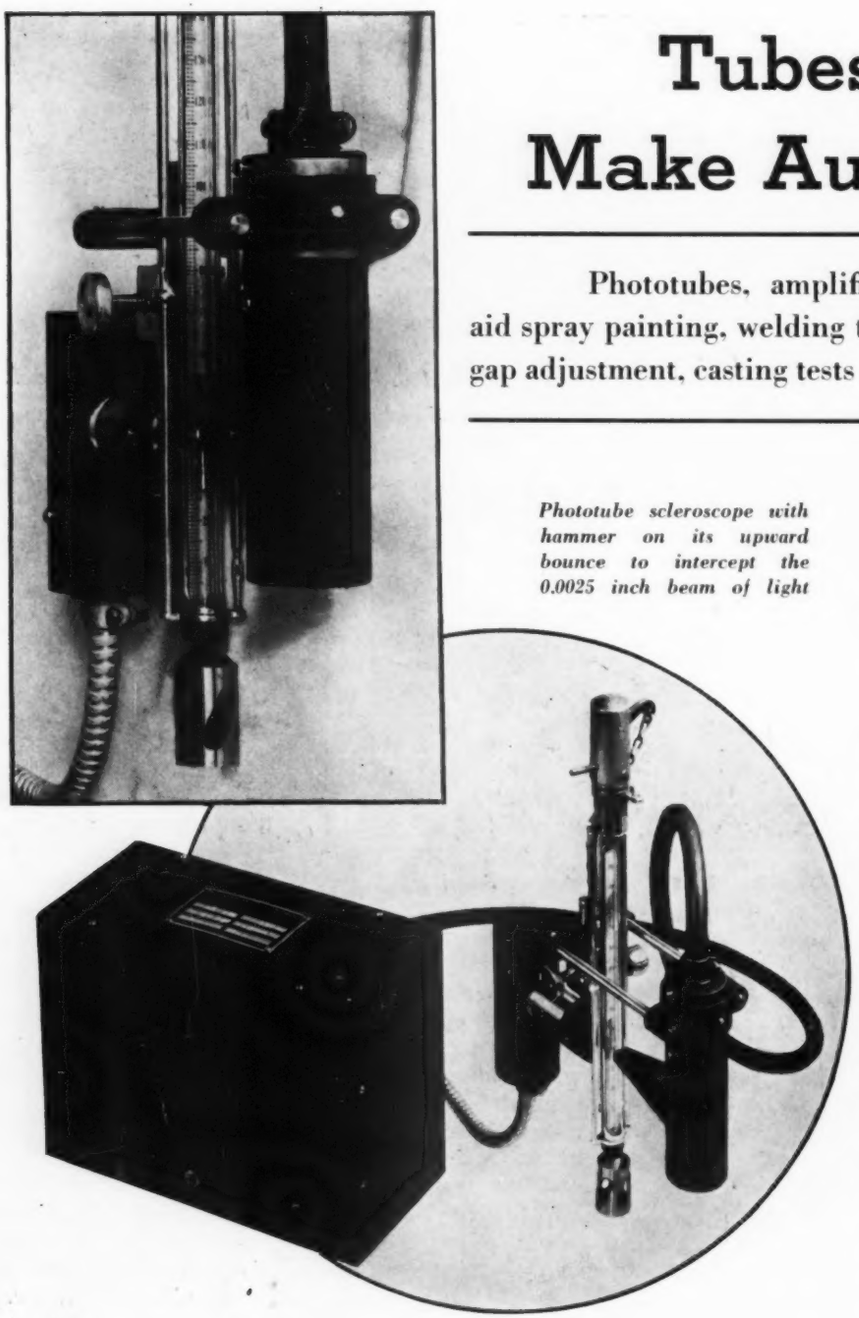
The 1936 Medal of Honor was awarded at the banquet of the Institute to Dr. George A. Campbell who recently retired from the Bell Telephone Laboratories, (See *Electronics*, p. 28, December, 1935). Dr. Campbell's work on electric wave filters and networks is well known to all communication engineers. At the same time the annual Morris Liebmann Memorial prize was awarded to B. J. Thompson of RCA Radiotron for his contribution to the vacuum tube art in the realm of the very high frequencies.

Other papers delivered at the Cleveland Convention, May 11, 12 and 13, were reported in May *Electronics*. The activities of F. H. Shepard, Jr. of RCA Radiotron and of H. J. Schrader of RCA Victor who are workers in applied electronics will be found described in Tubes At Work, this issue.

Tubes Help Make Automobiles

Phototubes, amplifiers, oscillators, microphones aid spray painting, welding timing, titration control, spark gap adjustment, casting tests

By R. A. POWERS
Electronic Control Corporation
Detroit, Michigan



Phototube scleroscope with hammer on its upward bounce to intercept the 0.0025 inch beam of light

ALMOST recent survey of the automobile and associated industries, reveals additional uses of photo-electric cells and electron tubes to save money, speed production, and insure a more uniform product.

Photocells and light beams have been used successfully to control electrically-operated air valves for actuation of automatic spray painting guns on parts conveyor lines. However, due to the excessive fog of paint it has been essential to clean the lenses of the light source and the phototube housing periodically to eliminate false operations. Recently several of the phototube units used in this type of application have been replaced with very stable capacity detector units. The capacity detector units used for automatic spray painting and automatic sand blasting use one or two standard radio receiving tubes in an oscillator circuit. The output tube controls an explosion proof relay capable of handling 20 amperes. In spray painting an explosion proof relay is essential to reduce fire hazard. A suitable variable condensor is provided in the units to adjust the sensitivity of the circuit in relation to the antenna used.

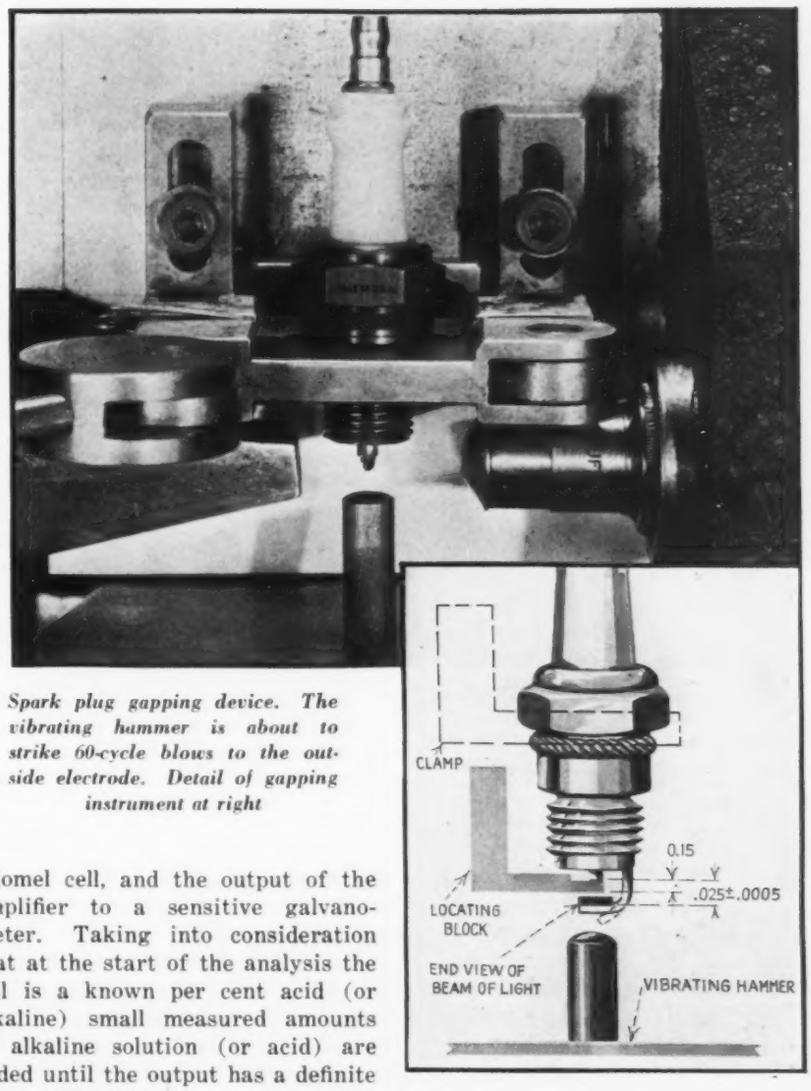
The installation of this type of unit for automatic spray painting is very simple. In one particular case where a cylindrical shaped article about 8 inches in height and 8 inches in diameter is to be automatically spray-painted as it passes on the conveyor, an inverted "U" shaped antenna, with clearance of 2 inches to 3 inches from the article is supported on insulators at the point where the spray guns are to be turned "on." As the article passes into the field of the antenna, the relay in the capacity detector closes, energizing a solenoid air valve. The air thus released to the spray guns starts the actual painting. The article passes on, and as it leaves the field of the antenna, the capacity detector relay becomes de-energized, turning off the air supply to the spray guns, awaiting the approach of the next article.

In divisions of factories where there is excessive smoke, dirt, and opaque fumes, this same type of unit is being successfully used to control conveyors to count articles, stop automatic machines when no stock is ready; and also open doors and turn on artificial illumination as a person approaches a dark dangerous area.

Welding Timers

While vacuum tube or electronic time delay relays are being used to reverse automatically, after a given period of time, gear lapping ma-

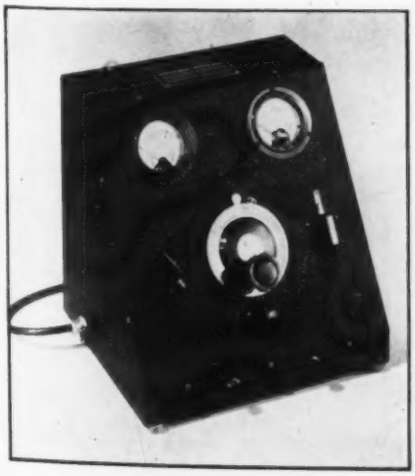
chines or to test fuel pumps for a given pumping volume in a specified time, nevertheless, one of the recent and most interesting uses is the application of this principle to welding timers. For clean, exposed spot welds, it is essential that time, pressure, and power be constant. Pressure and power are readily controlled; but when time has to be of the order of one or two cycles in duration, it has generally been necessary to turn to the large gaseous triodes because of the speed and ability to control large loads. Recently a welding timer which will handle 1,200 amperes and is capable of offering timing down to one cycle (based on 60 cycle) has been introduced and is receiving wide acceptance; because in place of gaseous type tubes, there are two type 27 receiving tubes in time delay circuits. The principle of overall operation is very unique. Needless to say the cost of tube replacement in this welding timer is cut to a minimum, a fact which contributes to its wide sale.



Spark plug gapping device. The vibrating hammer is about to strike 60-cycle blows to the outside electrode. Detail of gapping instrument at right

Titration Control

In the chemical laboratories involved in careful analysis and experimental developments of lead compounds for addition to automobile gasoline, extensive research has been carried out to determine at exactly what point an acid solution becomes neutralized, and before this solution becomes alkaline. A vacuum tube amplifier became the most logical solution. The input of the amplifier was connected to a calomel cell, and the output of the amplifier to a sensitive galvanometer. Taking into consideration that at the start of the analysis the cell is a known per cent acid (or alkaline) small measured amounts of alkaline solution (or acid) are added until the output has a definite sharp fall off to zero. At precisely this point the cell is neutralized and the volume of necessary reagent is used to plot a graphic curve, essential in corrected analysis.



Amplifier for acid-in-oil analysis

The first attempts in this new method of analysis were very discouraging; because the slightest drift in supply voltage resulted in complete loss of accuracy in resultant readings. It was found that room temperature changes caused enough drift in the B battery circuit to completely upset the readings. The B battery and current bucking battery caused the greatest trouble in the first amplifier used. The first amplifier was the conventional battery-operated one-stage unit using a triode the output of which was connected to a sensitive galvanometer (0—10 microamperes), with an external battery and adjustment as a current bucking device.

A circuit of the balanced type amplifier was finally developed for this analysis work, which is operating to satisfaction of the research chemist. The unusual resistance network in the C battery supply circuit, is to allow ample adjustment, because in some of the work done in the chemical laboratory with this unit, it is necessary to start with an input to the amplifier of negative five millivolts, proceed through zero and go to ten millivolts positive; while in the next analysis the input may be zero and proceed either positive or negative as the calomel cell changes polarity.

Spark Plug Adjustment

Manufacturers of spark plugs have experienced difficulty in obtaining a suitable method for production gapping of the electrodes of the plug. One of the final assembly operations is to bend the outside electrode to a position where it will

Complete phototube gapping device. Light source in cylindrical tube at left, phototube at right. The spark plug is in place in the clamp

form a 0.025 inch gap with the center or stationary electrode.

The practice in the past has been to insert a thickness gauge between the outside electrode and the center electrode. The outside electrode is then bent into place by a vibrating hammer. If the vibrating hammer is allowed to impart a few extra blows, the impact is transmitted through the thickness gauge to the center electrode—usually resulting in a cracked ceramic or porcelain. Even with an experienced operator the percentage of cracked porcelains is too high.

To control the vibrating hammer with a beam of light and photocell, so that the beam of light acted as the thickness gauge, presented several problems. The accuracy of the gap desired is plus or minus 0.001 inch; yet the relation of the center electrode to any other part of the plug may be plus or minus 0.010 inch. It is therefore impossible to locate the plug for this operation by any other point than the end of the center electrode.

The accompanying photographs show a general view of the complete device, and a close-up of the end of the vibrating hammer with a spark plug in position for automatic gapping. The sketch shows the general set-up of the locating block, clamp, beam of light and vibrating hammer.

The operation of the complete device is rapid, accurate, and simple. The operator inserts the plug in the clamp, with the center electrode against the locating block. A foot button makes momentary contact, which closes an electrically held relay. One contact on this relay energizes the 60 cycle vibrating hammer. With many rapid light blows the hammer bends the outside electrode until it eclipses the small beam of light. The plate relay of the photocell amplifier opens its contacts releasing the electrically held relay, thus stopping the vibrating hammer. The plug is removed, correctly gapped. The average operator gaps from 800 to 1,500 plugs per hour.

Tubes Applied to Scleroscope

An interesting electronic and mechanical device now under construction will automatically inspect a small hollow, completely finished, permanent mould casting which is the integral part of a large production automobile. The finished part must be automatically scleroscoped for hardness; checked for invisible cracks and sulphur flaws by the sound produced when struck like a bell; checked for all dimensions (diameter at three places, and height to 0.0001 inch and for thickness to 0.015 inch) and inspected for 1/32 inch diameter surface pin holes.

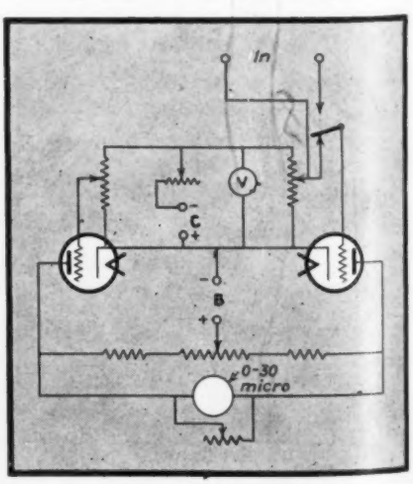
The complete inspection must be made at the rate of one part per second. If at the various stations of inspection, the part does not come up to specifications, it will be automatically rejected by a solenoid.

The photo-electric scleroscope has several unique features. It is shown, removed from the complete machine. The small diamond tipped hammer is drawn to the top of the glass tube by a constant vacuum derived from a small ventura in a water main. As the article indexes into a position for the check of surface hardness, the vacuum is released, allowing the hammer to fall. On the downward fall of the hammer, a cam operated switch on the entire machine opens the relay circuit of the photocell amplifier, but as the hammer comes in contact with the part under test, the circuit closes. The bounce of the hammer upward, determines the surface hardness. If the hammer bounces high enough to eclipse the 0.005 inch ribbon of light, the part passes on as "O.K. for hardness." If the hammer does not bounce high enough, the part is rejected at this station as too soft.

The second station of inspection required considerably more forethought and consideration of existing conditions. The flaws and gas holes in the castings cannot be seen with the human eye, because in the greater portion of cases, these flaws are internal. X-Rays were seriously considered; yet their use would require manual inspection, which was to be completely eliminated. It was found upon careful examination that the usual shape coupled with the fact that the finished castings were hollow, allowed a check for cracks and flaws by sound. The articles which were not cracked rang like a bell when struck a slight blow, while those that were cracked or had flaws, sounded "dead."

A contact microphone was first thought possible to pick up these sounds; but in order to have the duration of the ring undamped by a solid mechanical holding of the part while under inspection, it was found necessary to use a specially designed, very directional microphone. The microphone had to be directional to eliminate any unnecessary pickup of sound from the rest of the machine or the shop itself. To eliminate further any unwanted sounds to pass through the

[*Continued on page 55*]



Amplifier circuit used in oil analysis

Electronic Engineering

A discussion of the possibilities of the application of electron tubes to power generation, transmission, conversion problems. A portion of a talk by Dr. Alexanderson before the Institute of Electrical Engineers, Washington, D. C.

By E. F. W. ALEXANDERSON
Consulting Engineer
General Electric Company

ELECTRONIC engineering is still an infant but need not be introduced. Radio was well established in an important way for transoceanic communication when the electronic art took practical form and changed the whole picture. A similar evolution is now in progress in power engineering, although it is not as rapid.

The electronic devices used in power engineering are usually of the mercury vapor type as distinguished from the high vacuum tubes used in radio. The mercury arc in vacuum has been known and used for a long time under the name of mercury rectifier but its usefulness and adaptability were greatly increased when it was discovered that the arc could be controlled by a third element in the form of a grid or an igniter. We have thus a device that may be used as a plain rectifier, a controlled rectifier or an inverted rectifier.

Hot cathode tubes and igniter tubes are now available in units with single anode, whereas continuously excited mercury pool cathodes are made in the form of steel tanks of the multiple anode type. This divergence in the forms of practical development has led to some confusion in terminology. The steel tank type is popularly known as a rectifier, whereas the hot cathode and igniter devices are known as tubes. They are, however, intended to perform the same functions and each of these devices may be used either as a rectifier or as an inverter. It has been proposed that a common name should be adopted to comprise the various operative functions of rectifier, inverter and frequency changer. The name "mutator" has therefore been agreed upon. The device which it is intended to describe might be classified broadly as an electronic commutator. The name "mutator" therefore seems appropriate with a good linguistic as well as practical background. A mutator comprises a group of tubes or tanks with the associated circuits. The electronic device itself may be of the hot cathode or pool cathode type and of the tube type or tank type.

Some of the outstanding branches of electronic engineering which are being actively developed are:

Power transmission with high tension d-c, thyratron motors, frequency changers, transformation of direct current, torque amplifiers, electric welding.

The subject of power transmission by direct current has been with us a long time but recently it has assumed new importance. One of the reasons for this is the new developments in electronic devices which make a new technical solution possible. The other is the national interest in development of large sources of water power which can find adequate market only at great distances. A paper was given within the last year by Willis, Elder and Bedford describing an interesting new solution of direct current power transmission with constant current. A-C power of constant potential is changed into constant current by a reactance capacity network of the type that Steinmetz named "Monocyclic Square." The rectifier changes the constant alternating current to direct current which is transmitted at high tension and at the receiving station inverted back into constant current a-c. Another monocyclic network is then interposed which changes the constant current a-c back into constant potential alternating current.

Water-cooled igniter tube ZG-238

The constant current d-c system is particularly attractive for transmission through underground cables. There is good reason for assuming that cable insulation can sustain a d-c voltage several times higher than the a-c voltage without deterioration and thus d-c transmission through underground cables becomes possible where a-c cable transmission would be out of the question. A-C transmission lines must be carried cross country on high towers whereas with the high tension d-c cable it is likely that the public highway which is becoming more and more important for transportation, also will become the carrier of electric power with a d-c cable buried in the ditch.

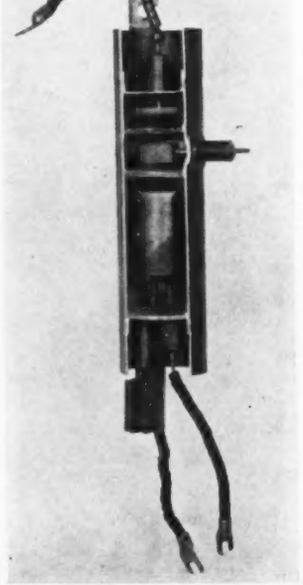
While constant current power transmission is a highly interesting solution, it cannot yet be taken for granted that d-c power transmissions in the future will always be of the constant current type. It is, however, not necessary for us at the

present time to attempt to predict whether this development will go in one direction or another, but it is important to realize that there are great problems ahead in the use and distribution of electric power and that the electronic art has furnished solutions for these problems.

The first electric motor was a d-c motor and even after the a-c motor had become widely used, the d-c motor was for a long time preferred because it was a variable speed motor. The advantages of a-c distribution, however, proved to be so great that it has become universal and d-c distribution, while it still remains is gradually being eliminated. This is in spite of the fact that the a-c motor, both induction and synchronous motors are constant speed motors. While the industry has adapted itself to the constant speed drive, there remain important applications where a variable speed a-c motor is needed. The thyratron motor is intended to meet this demand. It is a synchronous type of motor with a thyratron commutator which operates for all practical purposes as a d-c motor with variable speed control, although it consumes alternating current. A 400 hp. motor of this type has been built and delivered to the American Gas and Electric Company. The chances are that future large installations will use mercury pool tanks or igniter tubes in the place of the thyratron tubes which are more adapted to the moderate sized and small installations. We have thus a situation where the methods and objectives are the same but the choice of the electronic device is a matter of detail and expedience.

The significance of the mutator motor is not only that it solves the problem of a variable speed a-c motor but it points to a solution of other important problems in electric power distribution. A well recognized limitation of the a-c distribution system is that power can flow freely over an electrical network only when certain relationships of frequency and synchronism are observed. The d-c distribution system was not limited in this way and this has been one of the reasons for its use. The hope is now that the new technique of electronic engineering removes even this limitation from the a-c system. The connection between the mutator motor and this problem in power distribution may be explained in the following way. The mutator has the function of consuming power of one frequency and delivering it to the motor at another frequency. This control of frequency gives the motor its variable speed characteristics but it also proves the possibility of taking power from one power system and delivering it to another power system at a different frequency. It is also possible to deliver power to a system of the same frequency without the necessity of operating the two systems in synchronism. A transmission line may thus be established between two systems where for technical reasons it was previously impossible to exchange power. Such a link between two systems which previously could not exchange power may be called an asynchronous tie line or an asynchronous transmission. It has the characteristics of a d-c transmission but it also has the practical advantage that it adapts itself as an extension and an improvement of the a-c system making present facilities more useful.

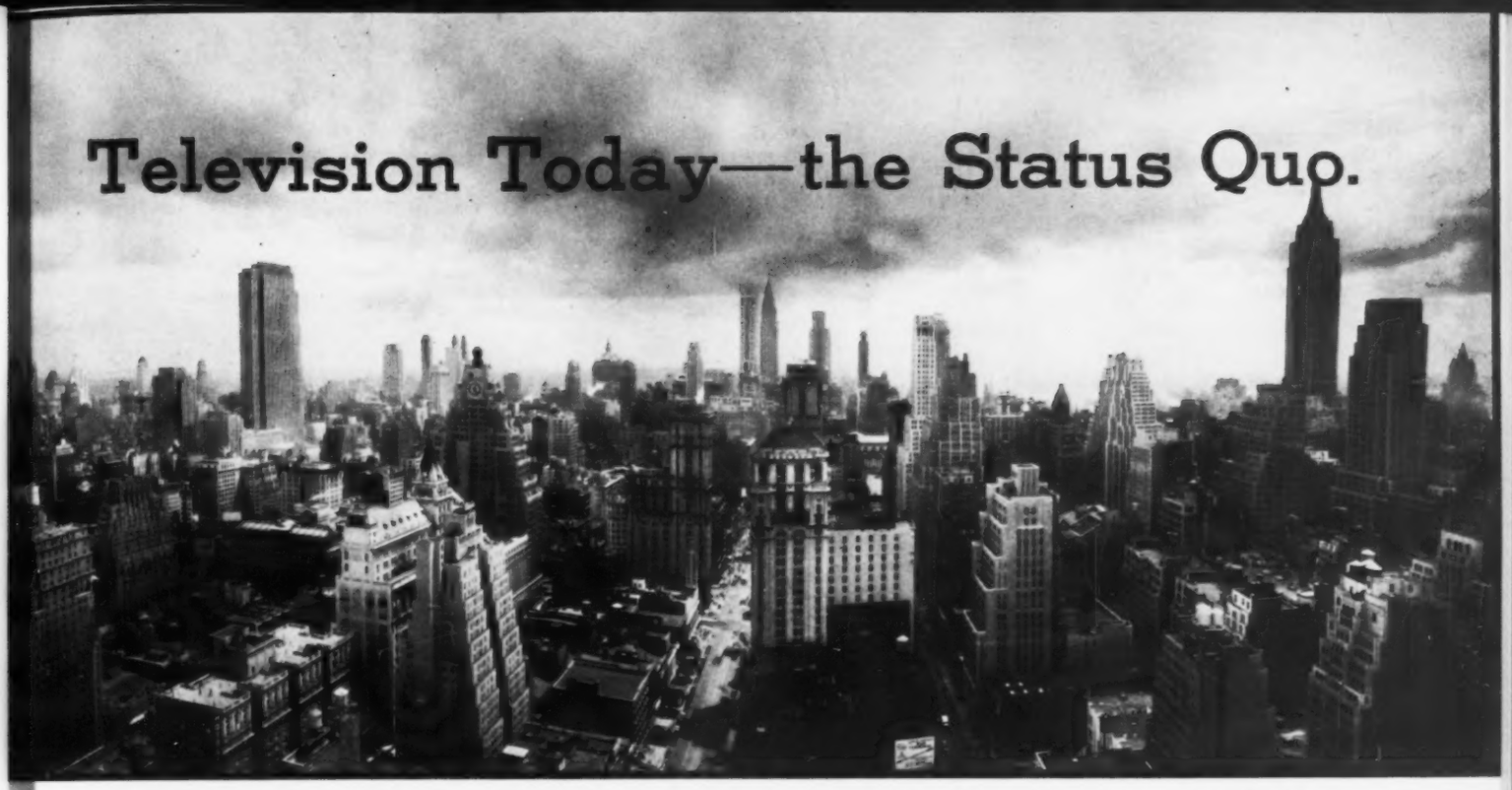
One of the immediate results of making a-c power distribution free from the limitations of frequency and synchronism will be the unification of systems which are now operated at different frequencies. For example, 40, 50 and 25 cycle systems may be tied together with the 60-cycle system by mutators which in that case may be described as frequency changers. Of greater importance may be the power exchange between 60-cycle systems which have so grown that extension or power exchange by synchronous tie lines becomes impractical. The broad object is thus to make large power sources available to large areas. The technical means whereby this is accomplished becomes a natural evolution. First we have the synchronous transmission which reaches to its well recognized limits. Then we have a synchronous a-c transmission or d-c transmission that may be used to tie together units that cannot be operated in synchronism. Finally we have the problem of transmitting power from great distances. This latter problem is partly an economic one and partly a technical problem. Insofar as it is an economic problem it cannot be intelligently discussed except in the light of the facts connected with each specific case. However, insofar as it is a technical problem we can say that there is no limit for electrical power transmission with either a-c or d-c. When the limits of synchronous a-c transmission have been reached it is possible to go still further with a synchronous a-c or d-c transmission.



Metal power rectifier, FJ-172

So far it has not been possible to transform direct current from one voltage to another without the use of rotating machinery, motor generators or dynamotors. With the mutator this becomes possible. Direct current has always been peculiarly adapted for electric traction but the voltage has not been high enough for economical distribution. With the electronic mutator used as a transformer of direct current it now appears possible to raise the trolley voltage to an efficient value for distribution say 12,000 to 25,000 volts, and deliver low tension direct current in the most efficient form to the motors. It would be premature to attempt to predict how such a system of traction would compare with the highly developed 25 cycle a-c system but here again is an example of the competition of ideas that is necessary for progress. The d-c transformer consists of a mutator that changes the power from high tension direct current into a convenient intermediary frequency, perhaps 100 cycles, and then converts it back into low tension direct current of variable voltage.

Television Today—the Status Quo.



In the coming field tests, television studios in the RCA Building (left) will feed signals by coaxial cable and by a u-h-f radio link to the main transmitter on the Empire State Building (right)

A review of progress in cathode-ray technique since 1934, the remaining problems, and the purposes of the field tests, on which future plans depend.

THE scarcity of information on current advances in television, especially on those made in this country, has at once piqued the curiosity of the technical reader and led to the assumption that very great, and therefore heavily guarded, progress has been made. While progress has been made, no improvements in principle, or in radically new apparatus, have appeared since the use of "light storage" in the Zworykin iconoscope and of electron multiplication in the Farnsworth image dissector. What advances have been made in the past two or three years are refinements of apparatus, a gradual increase in the fundamental dimensions (number of scanning lines, pictures per second, carrier frequencies, etc.) of the system, and great increases in the stability of the circuits used. These improvements are essentially matters of degree, not principle; they indicate that further work in the field, barring the possibility of a radically new concept, will probably follow along the same lines, that is, refinements of pick-up, transmitting, and reproducing apparatus and circuits. That the fundamental technical foundation for television service has been found in the use of electronic scanning and reproduction, and in the transmission of extremely wide-band signals in the ultra-high frequency spectrum can scarcely be doubted in view of the record. The necessity of scanning seems to be completely unavoidable, and the high degree of definition now possible with electronic methods of pick-up and reproduction must be equalled by mechanical systems before they can compete, even on a cost basis.

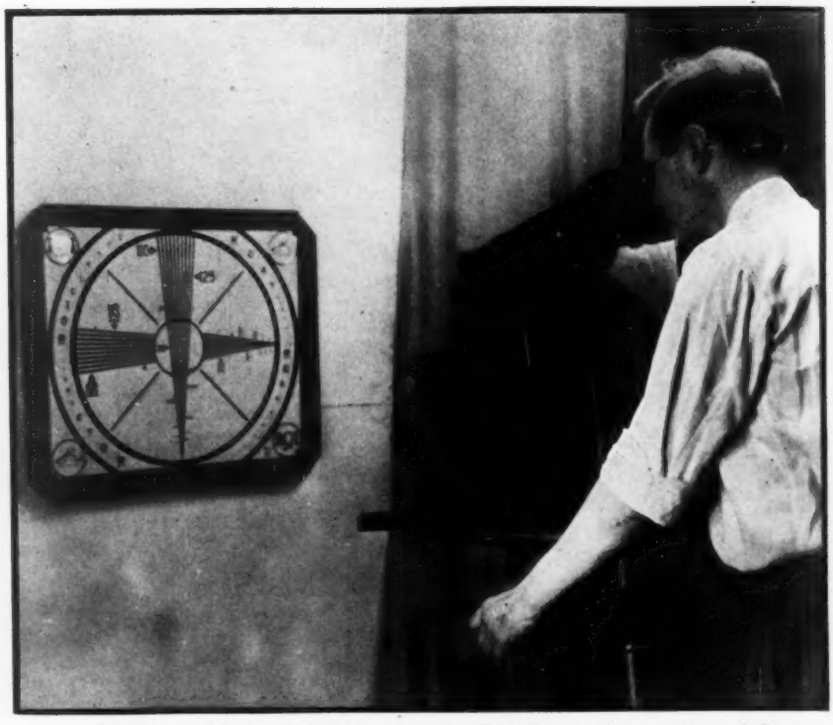
The fundamental question in television, once the scanning method is accepted as inevitable, is the question of the dimensions of the system. By way of bringing television up-to-date, therefore, it is interesting to compare these dimensions as they existed in 1933 with those of the present, and with those of the immediate future. In 1933, the scene to be transmitted was scanned with 240 lines, which were sent in direct sequence, the complete picture being scanned in approximately 1/24th of a second. Such a 240-line, 24-frame picture required a total band-width of about 2.05 megacycles,[1] corresponding to a maximum modulation frequency of 1.025 mc. The signal was sent on a carrier frequency in the neighborhood of 40 mc. The picture frequency, 24 per second, was the same as that of standard motion picture film, which could therefore be scanned directly during projection.

Since 1933, the dimensions have been changed considerably until at present two experimental systems using electronic units have been set up as follows: each picture is scanned into 343 lines, the complete picture being scanned 30 times per second. The picture is covered twice within each scanning cycle, the odd numbered lines being presented by the eye in the first 1/60 of a second, the even numbered lines in the second 1/60th. This "interlacing" corresponds to the "chopping" action employed in projecting motion pictures, in which each frame is interrupted once by a light shutter; it has the effect of greatly reducing the flicker. The band-width required for these 343-line, 30-frame pictures is approximately 5.2 mc.,

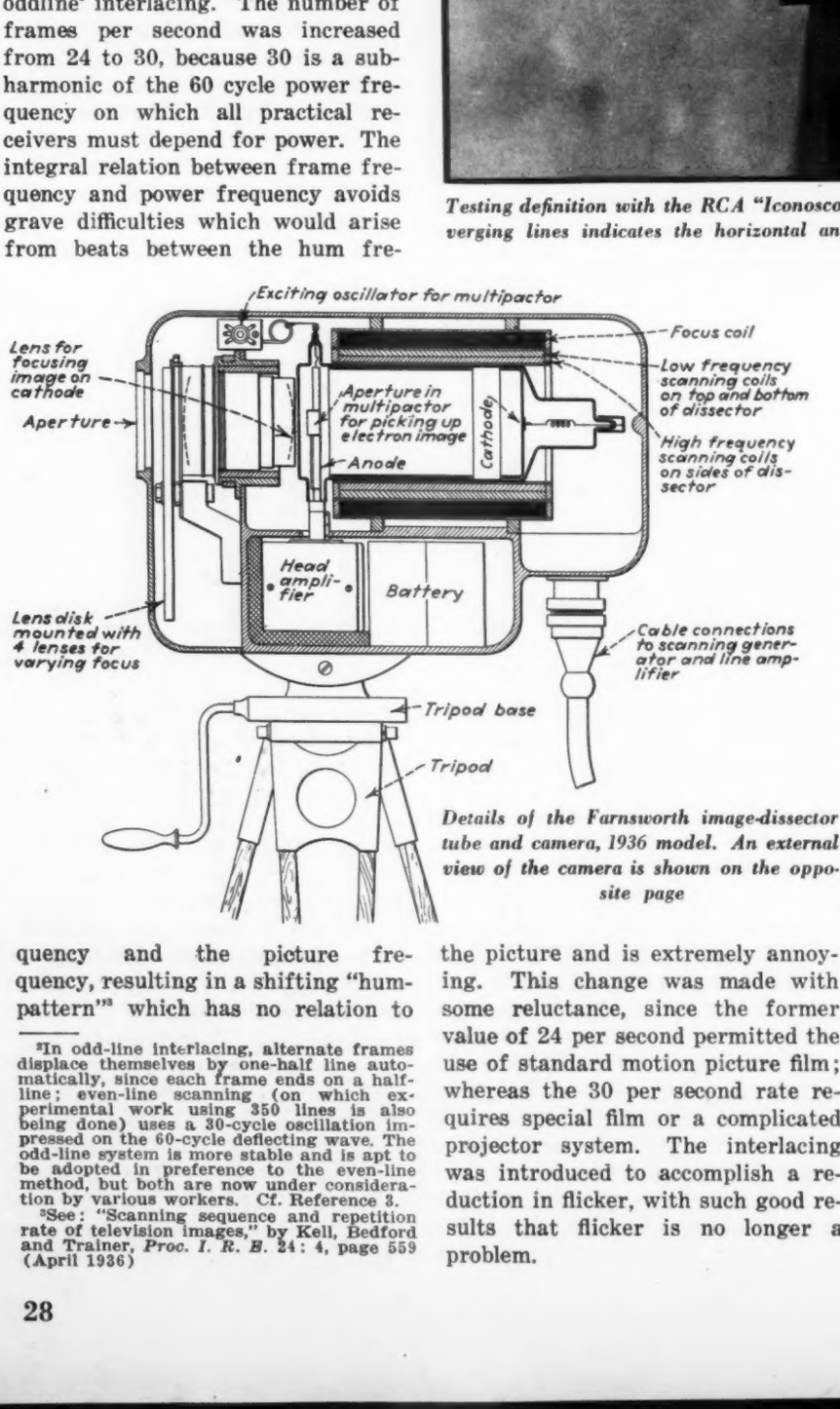
[1] See "An Experimental Television System" by E. W. Engstrom, *Proc. I.R.E.* 22: 11, Page 1242 (November 1934). This paper and others in the same issue by Kell, Bedford, Trainer, and others of RCA Victor, give an excellent resume of the state of the art in 1933. See also: "Television—A survey of present day systems," *Electronics*, October 1934, page 300.

corresponding to a maximum modulation frequency of 2.6 mc. These figures are based on the same assumptions as were used in computing the band required for the 240-line, 24-frame pictures, that is, the formula used is $f = \frac{1}{2}$ (no lines)^2 $\times$ aspect ratio $\times$ (no. pictures per second), where the aspect (width to height) ratio is 4/3, and f is the maximum modulation frequency.

The reasons for these changes in the dimensions are simple. The number of lines was increased from 240 to 343 to improve the definition of the picture, that is, to increase its entertainment value. The odd number 343 was chosen to permit oddline[2] interlacing. The number of frames per second was increased from 24 to 30, because 30 is a subharmonic of the 60 cycle power frequency on which all practical receivers must depend for power. The integral relation between frame frequency and power frequency avoids grave difficulties which would arise from beats between the hum frequency and the picture frequency, resulting in a shifting "hum-pattern"[3] which has no relation to the picture and is extremely annoying. This change was made with some reluctance, since the former value of 24 per second permitted the use of standard motion picture film; whereas the 30 per second rate requires special film or a complicated projector system. The interlacing was introduced to accomplish a reduction in flicker, with such good results that flicker is no longer a problem.



Testing definition with the RCA "Iconoscope". The degree of separation of the converging lines indicates the horizontal and vertical resolving power of the system


Exciting oscillator for multipactor
Focus coil
Lens for focusing image on cathode
Low frequency scanning coils on top and bottom of dissector
Aperture
Aperture in multipactor for picking up electron image
Cathode
Anode
High frequency scanning coils on sides of dissector
Head amplifier
Battery
Lens disk mounted with 4 lenses for varying focus
Cable connections to scanning generator and line amplifier
Tripod base
Tripod

Details of the Farnsworth image-dissector tube and camera, 1936 model. An external view of the camera is shown on the opposite page

As for the immediate future, it is known that important workers in the field are actively considering a further increase in number of lines to the neighborhood of 450 (441 for odd-line interlacing, or 450 if even-line interlacing is finally decided upon). This increase has been dictated by two factors: a desire to improve further the entertainment value of the picture, and the prospect of larger pictures, which require a somewhat greater degree of detail for the same degree of satisfaction. The present number of frames and the two-to-one scheme of interlacing seem to be satisfactory; it seems likely that they will not be changed. For a 441-line, 30 frame picture the total band-width required for transmission is 8.6 mc., i.e. a maximum modulation frequency of 4.3 mc. This enormous band-width is considerably wider, probably, than will be required. For one thing, the time required for synchronizing (control functions) has been reduced from about 10 per cent to only a few per cent. In the second place, Engstrom and others have shown that equal resolution of the picture in vertical and horizontal directions is obtained with a band-width only 0.64 times as great as that given by the formula, and that maximum economy of band-

[2]In odd-line interlacing, alternate frames displace themselves by one-half line automatically, since each frame ends on a half-line; even-line scanning (on which experimental work using 350 lines is also being done) uses a 30-cycle oscillation impressed on the 60-cycle deflecting wave. The odd-line system is more stable and is apt to be adopted in preference to the even-line method, but both are now under consideration by various workers. Cf. Reference 3.

[3]See: "Scanning sequence and repetition rate of television images," by Kell, Bedford and Trainer, *Proc. I. R. E.* 24: 4, page 559 (April 1936)

width is obtained by using this factor. If this is done, the 441-line 30-frame picture can be transmitted in a band about 5.5 mc. in width, corresponding to a maximum modulation frequency of 2.75 mc.

Whether or not the limit in desirable detail has been reached in a picture of 441 lines is very difficult to say, since the public preference cannot be determined without trial. But this much can be said: a picture of 441 or 450 lines gives all the detail that the eye can use, provided that the picture is viewed from a distance four times as great as picture height. For a picture seven inches high, this means a viewing distance of 28 inches, which would seem to be as close to the screen as the average viewer would want to get. As evidence of public preference, the seats in a motion picture theater which fill up first are those situated a distance from the screen equal to four times the picture height. Apparently the solid angle subtended at the eye by the screen under these conditions gives a satisfactory compromise between margin distraction on the one hand, and the necessity of moving the head to follow the action on the other.

The difficulty of utilizing a five mc. channel has long been appreciated. In the first place, "flat" amplifiers required to cover this range have very small gains per stage, requiring a large number of tubes. Likewise modulation at high levels over this range is extremely difficult; the modulation reactor, for example, must be flat within a small part of a db from 60 to 2,500,000 cycles. In the receiver, likewise, the gain per i-f stage is small, necessitating large numbers of tubes. It appears that a five mc. channel provides plenty of room into which the art can expand as its circuits are improved.

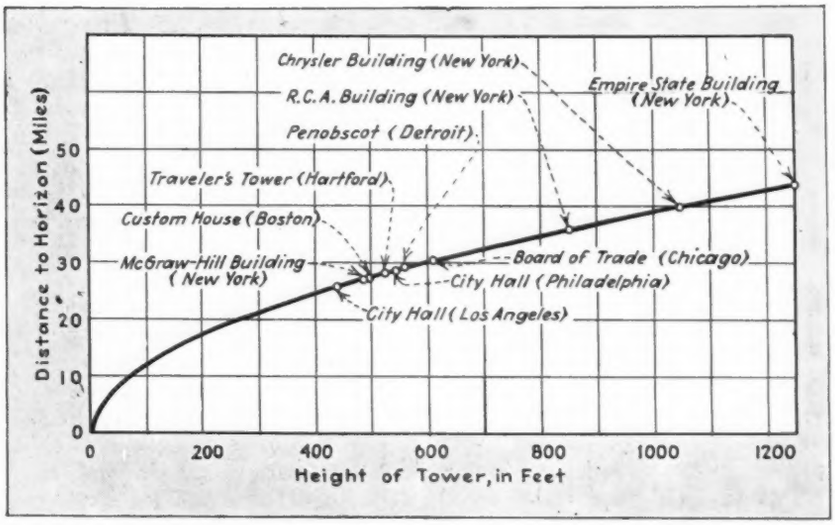
A final dimension of the system, somewhat less fundamental than the others, is the separation between the visual and audio carrier frequencies. If a five mc. channel is used for the visual signal, the separation between sight and sound must be more than 2.5 mc. Otherwise the upper sidebands of the sight channel will interfere with the sound. The plan now in favor is to have each visual carrier grouped with its associated sound carrier, with a fixed frequency separation of about 3 mc. between them. In this manner, tuning for the sound carrier will automatically center the receiver circuits on the visual carrier. This necessary separation adds perhaps another megacycle to the total width of the sight and sound channel, or a total of six mc. in all. Then between 42 and 86 mc. (not including the 56-60 mc. amateur band which is not available for television use) there is room for seven channels. That is, seven television stations may operate simultaneously in a given area without causing interference with one another, within the experimental television bands as they are now assigned. The short interference range (approximately 100 to 200 miles) will permit duplication of these channels at 200 miles separations.

Apparatus and Circuit Refinements

Aside from the band-width and dimensional factors discussed above, very considerable advances have been made in the improvement of detailed parts of the transmitting and receiving equipment. These advances can best be illustrated by a description of equipment viewed in two television laboratories. The first, the RCA Victor Research Laboratories in Camden, were visited by the editors on April 24 last. A transmitter of thirty watts power, (output from two 802 tubes), with a directional antenna, was used to direct a signal to the receiver, distant about one mile air-line. The camera pick-up was a conventional Iconoscope, scanned 343 lines, 30 frames. The signal voltage was pre-amplified at the television camera, and sent over a short length of coaxial cable to the main amplifier and modulator. The apparatus was one hundred per cent electronic in operation, even to the generation of synchronizing impulses. In 1933, a revolving disc (containing apertures through which light was admitted to a photocell) was used for producing the highly peaked waveforms necessary for synchronizing; now a specially constructed tube generator is used which can provide even greater accuracy than the mechanical method.

The visual signal (3 mc. total width) was sent on a carrier of 46 mc., and contained side-band frequencies from 60 cycles to 1.5 mc. The receiver, which needs a signal level of about 5 mv/m to operate satisfactorily, takes both sight and sound carriers into the r-f stage. An oscillator beats with the two carriers to give i-f frequencies of 10 to 11.5 mc. for the sight channel, and 8.75 to 9 mc. for the sound, the latter range corresponding to a high-fidelity sound program. One tuning

Above, unretouched photo of a 343-line, 30-frame, 5" by 7" television image taken at a distance of 12 feet from the cathode-ray screen with a Leica camera, f2.0, ¼ sec. exposure. The photographic enlargement (about 10 times) has destroyed the detail, but the sharp contrasts now available are clearly visible



Relation between the height of buildings (on which television antennas might be placed) and the horizon distance, which is an approximate measure of the radius of the service area. The highest building in each of seven cities is included

dial controls the oscillator and r-f stage, so that when the sound is correctly tuned, the visual signal is properly aligned with respect to the i-f of the sight channel. The receiver contains 33 tubes, including the high voltage rectifiers which supply 6,000 volts accelerating voltage to the cathode ray "Kinescope." The cathode ray tube is mounted with its long axis vertical, the screen being uppermost, facing upward toward the top of the console and protected by a shatterproof glass plate. A front-reflecting steel mirror is mounted on the swinging top of the console so that the image is reflected from the screen of the tube outward toward the viewer in front of the set. Sound controls for volume, high and low frequency tone are provided, sight controls for contrast, detail, and brightness, synchronizing, scanning and position controls for horizontal and vertical directions and a focus control, making a total of 14 knobs, seven on the front of the cabinet, seven under the folding top.

The "Kinescope," which is expected to have a long service life, has a screen composed of a yellow-green willemite compound of appreciable time lag. The total power drain of the receiver shown was 350 watts. The receiver is similar to those to be used in the projected field test, described below. The pictures received (5 by 7 inches in size) were of excellent contrast and detail, and were interfered with only slightly by the ignition systems of passing automobiles, the sound channel being apparently more adversely affected than the sight. The receiver, despite its highly professional and commercial appearance was manifestly an experimental model.

Among the advances made in apparatus are several reported by Philo T. Farnsworth. In the "Image dissector" tube, which serves as the photoelectric pick-up device of the television camera in the Farnsworth apparatus, the photoelectric cathode has now achieved a sensitivity of 50 micro-amperes per lumen, and the electron multiplier in the tube provides an overall gain of 100, compared with about 25 previously possible; this increase has been accomplished without increasing the noise level. By using type 955 acorn tubes in the head amplifier of the dissector tube, considerable increases in amplifier efficiency have also been gained.

Considerable research has been made by Farnsworth and others into the possibility of producing a white fluorescence in the cathode-ray tube screen. A combination of Willemite (green), calcium tungstate (blue), and zinc borate (yellow) will give a brilliant white light. In using such materials, the time-lag of each component must be matched to that of the others, so that moving objects in the field do not appear to leave colored trails behind them.

The high quality 450-line signal requires an electron gun of great capabilities, which will give a very small and brilliant spot, and which can be modulated accurately over wide ranges. A new form of gun developed by the Farnsworth Laboratories makes use of small emitting surface operated as near to the saturation point as is consistent with good grid modulation, with element spacings and aperture diameters designed for small intense beam output.

An entirely new type of reproduction tube, which is still very much in the experimental stage, is the so-called projection type of tube. In this tube the screen is not fluorescent, but is composed of a special material which becomes incandescent under the action of the electron current in the cathode-ray beam. The picture thus formed is extremely brilliant, and can be readily projected through a lens system to a screen, in the manner of motion pictures. The difficulty thus far encountered is the extremely short life of the incandescent material. But large black-and-white pictures produced by this means seem to be coming.

Larger cathode-ray tubes are also being made, but it seems to be general opinion that pictures larger than 9 by 7 inches can be produced in cathode ray tubes only at great cost and with great difficulty in controlling the light spot. A new process developed by the Corning Glass Works makes it possible to fabricate the glass shell of the cathode-ray tube much more cheaply than it has been possible heretofore. Briefly, the end-plate (screen) of the tube is molded separately from high quality glass, and then fused to the funnel-shaped part of the tube, which may be of much inferior optical quality. What the expense of a good cathode ray tube will be, under production methods of manufacture, is hard to guess. A British tube for pictures 8 by 6 inches is now selling for £12 ($60), but this price is probably higher than that of an equivalent American product. This tube produces nearly black-and-white images.

Scanning and synchronizing circuits in the receiver have been greatly improved. The scanning sweep circuits are so nearly linear that the distortion introduced by

[*Continued on page 53*]

New High-Frequency Allocations

Federal Communications Commission assigns various broadcast services new space in the ether, gives new frequencies to television, fixes new stability requirements, and aids the development of wavelengths below 200 meters

Recognizing the fact that new broadcast services outside the regular broadcast band are daily becoming more imminent from a practical standpoint, the Federal Communications Commission, Broadcast Division, has allocated certain frequencies in the region above 1500 kc. on a new basis, and has laid down new rules governing television, facsimile, relay, foreign broadcasting, rebroadcasting and other entertainment transmissions, in an order adopted May 21.

Television

As of July 1, existing television stations using the 2000-2100 and 2750-2850 kc. bands will be required to find space in the new bands of 42-56 mc., 60-86 mc., and 110 mc. and up except the amateur band 400 to 401 mc. It will be noted that all television stations in the future must go on the ultra-high frequencies where, as every engineer knows, is the only possible place for good transmission of high quality pictures. The region from 56 to 60 mc. is now occupied by the "5-meter" amateur band. This new allocation amounts to an increase of bandwidth of 5 mc. given over to television.

Facsimile

Transmission of still pictures is recognized as a future possibility. No definite frequencies are assigned, but there are many individual channels and small bands assigned for experimental broadcast purposes and on these channels and bands may go the facsimile experimental stations. As in other assignments on the experimental basis, facsimile stations are required to have a schedule of research and development carried out by capable hands, and regular reports on the progress of the experiment are to be transmitted to the FCC.

Of most immediate importance is the assignment of 5 groups of frequencies for use of "apex" stations, or broadcast stations operating on frequencies higher than 25,000 kc. and offering a high fidelity local service. In this classification there are already several stations licensed to operate and it is understood that 40 additional stations have applied for permits. It is here that the broadcast industry must look for more ether space. Group A is around 26,000 kc. Group B is about 26,500 kc. (Those groups are taken from the former foreign broadcast assignments.) Group C lies between 31.6 and 41 mc. Group D between 40.3 and 41.8 mc. and Group E is in the general region above 86 mc. Groups A and B carry bandwidths of 30 kc. Group C and E will have an assignment of 30 kc. for amplitude modulation or 200 kc. for frequency modulation. Group D is assigned for frequency modulation only. Thus the FCC recognizes the merit in further experiment on this method of modulation, and sets aside a region in which this work can take place.

Relay Broadcast Stations

Where wire facilities for communication are not available, programs and orders concerning these programs are regularly sent by high frequency radio to the broadcast station or network. There are five regions in which these short distance transmissions may take place. Licenses will be issued only to holders of licenses for regular broadcast stations, thus eliminating the possibility of a rental system being built up. Under special circumstances, however, other arrangements may be made, so that temporary authority may be granted other persons to handle this kind of transmission. Authority must be sought from the FCC for each transmission by relay broadcasting and essential information must be sent as to the hours of operation, etc.

Frequencies between 6,000 kc. and 26.6 mc. have been assigned for foreign broadcasting since the Madrid Conference. The interesting point about the regulations as of July 1 is the fact that no licenses will be issued for stations of less than 5 kw. in power. Here the FCC realizes the futility of cluttering up the ether with low powered, ineffective transmitters. Here again the applicant is required to have a program of research and experiment. Channels between 25,625 and 25,875 kc. are now assigned here.

Rebroadcasting

Stations may now rebroadcast programs originating in another radio station without authority of, but with notice to, the FCC, provided, of course, the originating station is agreeable. This rule is applicable, however, only to stations existing in the present broadcast band and with programs originating in this country. No station outside the regular broadcast band may rebroadcast programs without authority, nor may any station broadcast foreign programs without authority of the FCC.

Special Broadcast Stations

The three channels, 1530, 1550, 1570, assigned for research and study, have all the regular broadcast band rules applied to them. The licensee must operate his station in such a manner that its upkeep is reasonably independent of the income derived from the transmission of sponsored programs.

The complete spectrum considered in the recent orders will be found on the next page with the new assignments as laid out by the orders of May 21.

BROADCAST SERVICE ALLOCATIONS

1.5 to 400 Megacycles

As set up by the Federal Communications Commission, May 21, 1936

Frequency Region (Megacycles)	CLASS OF SERVICE: Special (High Fidelity)	Relay Pick-up	Experimental
1.500 - 2.000	1.530	1.606 (B)	1.614
	1.550	1.622 (A)	
	1.570	1.646 (C)	
2.000 - 4.000		2.022 (B)	2.396
		2.058 (A)	2.398
		2.090 (C)	2.400
		2.102 (B)	
		2.150 (A)	
		2.190 (C)	
		2.758 (B)	3.490
		2.790 (A)	3.4925
	International	2.830 (C)	3.495
4.000 - 7.000	6.020 (A)		4.795
	6.040 (A)		4.7975
	6.060 (A)		4.800
	6.080 (A)		6.420
	6.100 (A)		6.425
	6.140 (A)		6.430
7.000 - 12.000	9.510 (B)		8.650
	9.530 (B)		8.655
	9.570 (B)		8.660
	9.590 (B)		
	11.710 (C)		
	11.750 (C)		
	11.770 (C)		
	11.790 (C)		
	11.810 (C)		
	11.830 (C)		
	11.850 (C)		
	11.870 (C)		
	11.890 (C)		
12.000 - 20.000	15.110 (D)		12.855
	15.150 (D)		12.8625
	15.170 (D)		12.870
	15.190 (D)		
	15.210 (D)		
	15.230 (D)		
	15.250 (E)		
	15.270 (E)		
	15.290 (E)		
	15.310 (E)		
	15.330 (E)		
	17.760 (F)		17.300
	17.780 (F)		17.310
	17.800 (F)		17.320

Frequency Region (Megacycles)	CLASS OF SERVICE: International	Relay Pick-up	Experimental	High-Frequency (u-h-f) Local Service	Visual (Television)
20.000 - 30.000	21.460 (G)		23.100	25.950 (A)	
	21.480 (G)			26.050 (A)	
	21.520 (G)			26.100 (A)	
	21.540 (G)		25.700	26.150 (A)	
	25.625 (H)				
	25.650 (H)				
	25.675 (H)		26.000	26.400 (B)	
	25.725 (H)			26.450 (B)	
	25.750 (H)			26.500 (B)	
	25.800 (H)			26.550 (B)	
	25.825 (H)		27.100		
	25.850 (H)				
	25.875 (H)				
30.000 - 42.000		31.100 (D)	30.100	31.600 (C)	
			31.100	35.600 (C)	
			31.600	38.600 (C)	
			33.100		
		34.600 (D)	34.600		
			35.600	40.300 (D)	
			37.100	41.000 (C)	
		37.600 (D)	37.600	41.200 (D)	
			38.600	41.600 (D)	
			40.100	41.800 (D)	
		40.600 (D)	40.600		
			41.000		
42.000 - 86.000 (except 56.000 to 60.000)					42.000 to 56.000 60.000 to 86.000
Above 86.000 (Except 400 to 401)		Any four frequencies (E)	86.000 to 400.000 401.000 and above	Any four frequencies (E)	Any two adjacent frequencies above 110.000 (except 400 to 401)

NOTES: International: Where desirable, one license and call letters can authorize one frequency from each required group (A, B, C, D, E, F, G, and/or H), but not for simultaneous operation

Relay (Pick-up): Groups A, B, C, assigned in rotation in each metropolitan area, group D to all stations, group E on request

High-Frequency (u-h-f): Groups A and B, amplitude modulation (30 kc. max. bandwidth), groups C and E, either amplitude modulation (30 kc.) or frequency modulation (200 kc. max. bandwidth). Group D, 200 kc. frequency modulation only

Society of Motion Picture Engineers Spring Meeting

At the Spring Meeting of the Society of Motion Picture Engineers many papers of interest to sound engineers were presented. The following brief summaries are of those papers which have especial interest to readers of *Electronics*.

Burton F. Miller, Warner Brothers First National Studio presented data showing the harmonic distortion in variable density records. He showed that low frequency distortion was almost exclusively due to departure of the overall photographic gamma from unity, while the distortion at high frequencies was dependent upon the velocity of the light valve ribbons.

The acoustic design of music scoring stages was discussed by C. M. Mugler of the Acoustical Engineering Company, Los Angeles. A scoring stage built at Columbia Pictures Studio was described. The stage follows a new innovation in architectural and acoustic design based on the controlled reflections and diffusions of sound waves, discarding the "live and dead end" theory of acoustic design which has been greatly used in the past.

Further data on studio acoustics were given by D. P. Loye of ERPI who gave rules to avoid poor quality when using more than a single microphone for pick-up, the proper qualities for scoring stages, and the benefits of proper damping of studio walls and ceilings.

A uni-directional microphone to improve the ratio of direct to reflected sounds and to discriminate against other undesirable sounds was described by Harry F. Olson of RCA Manufacturing Company. It is a combination of the bi-directional ribbon microphone which is a pressure gradient instrument in which the response corresponds to the velocity component in a sound wave, and the pressure ribbon microphone which is resistive controlled and whose response is a measure of the pressure component of a sound wave.

Harry H. Hall, Cruft Laboratory, Harvard University, described a sound analyzer built at Cruft and explained the desirability of knowing the frequency and amplitude of the various components and the phase relation between components in a sound wave.

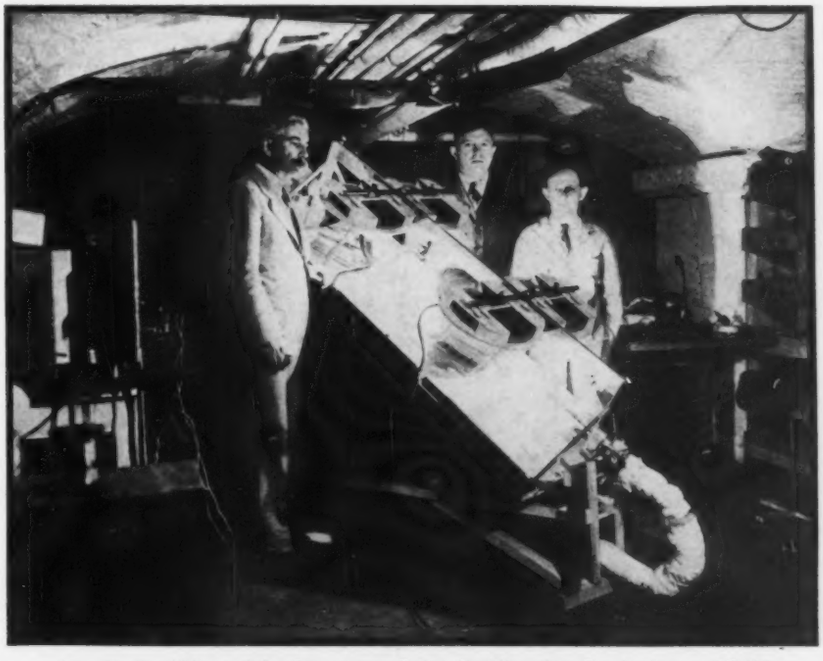
The theory and application of photoelectric exposure meters was covered by A. T. Williams of the Weston Electrical Instrument Company. The elementary theory of exposure, the application of exposure meters to still and moving picture photography and to black and white as well as color photography were discussed. His aim was to show the user how to achieve originality in picture making by means of the photoelectric tool now in so many photographers' hands.

The use of a phototube and light beam in timing horse races was described by S. M. Honan of ERPI. The electric clocks used are driven by a crystal-controlled source of 200-cycles. These clocks are photographed together with the position of the horses at regularly spaced intervals around the track.

A new monitoring telephone receiver of high fidelity characteristics was described by Harry F. Olson of RCA. The new type of vibrating system compensates for the loss of low frequency response due to the normal leak between the ear cap and the ear. Uniform response is maintained at the high frequencies by employing a system of small effective mass reactance. Experimental data as obtained on an artificial ear were given showing the effect of the acoustic leak on the response of various types of telephone receivers. Subjective tests were also described and data given which corroborate the tests on the artificial ear.

Barton Kreuzer of RCA Manufacturing Company read a paper on recent improvements in variable-width recording systems; G. A. Morton and G. L. Dimmick, both of RCA Manufacturing Company, gave papers already described to some extent in *Electronics*. Dr. Morton's papers dealt with the electron microscope (see *Electronics* November 1935) and Mr. Dimmick described his recent work with the use of ultra-violet light in recording on film (see *Electronics* March 1936, page 8 and frontispiece of this issue).

NEW EFFICIENCY IN SOLAR HEAT CONVERSION



Dr. C. G. Abbott, left, Secretary of the Smithsonian Institution, with his newly developed solar engine which is capable of utilizing fifteen per cent of the energy it receives from the sun

TUBES AT WORK

CONTRIBUTIONS to the art of making tubes work are taken this month from the I.R.E. Convention papers of F. H. Shepard and H. J. Schrader. Current multipliers, light intensity indicators, cathode ray tube applications, etc.

Direct Current Multiplier

AT THE Cleveland I.R.E. meeting in May, this year, F. H. Shepard of RCA Radiotron described several new circuit kinks which will be useful to engineers doing unconventional things with electron tubes. One such circuit is shown in Fig. 1. This is useful in the measurement of small phototube currents, in the measurements of leakage currents, or any other small currents in high impedance circuits. If test condensers are connected in place of C_1, I_1 will be proportional to the leakage of the condenser expressed directly in units of resistance per unit of capacity.

The circuit operates as follows:—signal current I_1 discharges condenser C_1; after the charge on C_1 has been reduced to a certain value the buffer stage grid voltage will allow the current through the buffer stage to be sufficient to create enough voltage drop across the cathode load resistor to decrease the bias on the 885 gas triode and cause the tube to "break-down"; then C_2 is discharged and is then charged in the opposite direction in a manner known to those familiar with the operation of gas triode relaxation oscillators to a value equal to E_1 minus twice the tube drop. While C_2 is being discharged through the 885, C_3 holds the cathode of the buffer stage at an essentially constant potential and C_1 is charged to a potential equal to the potential change across C_2, modified by a factor F_1 determined by the position of the slider on R_4. This is true when the plate potential of the buffer stage is adjusted so that the 885 breaks down at the instant that the control grid starts to draw grid current. This adjustment can be made by varying the slide on R_4 until the 885 ceases to relax and then backing off on the control slightly. The output meter M_1 reads $I_2 + I_1$ and meter M_2 reads $I_2 - I_1$, but as I_1 is usually extremely small compared to I_2, $I_1 + I_2$ and $I_2 - I_1$ can be generally considered equal to I_2 and the equation.

$$\frac{I_1}{I_2} = \frac{C_1}{C_2} F_1$$

can be written without appreciable error as

$$\frac{I_1}{I_2 + I_1} = \frac{C_1}{C_2} F_1$$

$$\text{or} \quad \frac{I_1}{I_2 - I_1} = \frac{C_1}{C_2}$$

Grid to cathode and grid to plate capacities of the buffer stage or any capacities in the input circuit are not to be considered a part of C_1 in the computation of the current ratios in the circuit. When the 885 discharges C_2, C_1 is charged as explained above to a voltage equal to the voltage change across C_2 times F_1. After C_2 is allowed to charge back to normal through resistor R_6 the charge across C_1 is allowed to distribute itself between C_1 and C_x without changing its actual value. C_x is the sum of all the capacities from grid to ground, this includes the capacities of the grid to plate and grid to cathode of the buffer stage and the capacities in the signal current source. Since this is true a definite current will remove this charge in a definite time regardless of the size of C_x.

The most accurate form of the expression for current ratios in this circuit is

$$\frac{I_1}{I_2} = \frac{C_1}{C_2} (F_1) (F_2)$$

The accuracy of this formula is probably as great as the accuracy of the reading of the output meter, when I_2 is equal to the meter reading M_1 minus I_1, or I_2 *is* equal to $(M_1 + M_2)$ /2, when F_1 is a correction factor due to the setting of the slider on potentiometer R_4 and F_2 is a correction factor due to the time of conduction per cycle of the 885.

Practically all of the time C_1 is being discharged by I_1 the plate current of the buffer stage is zero. This means that there can be no gas current to the grid during this time. The heater voltage of the buffer stage is lowered to reduce the grid emission, and the heater is returned to a potential positive with respect to the grid of the buffer stage to avoid the possibility of emission from the heaters to the grid.

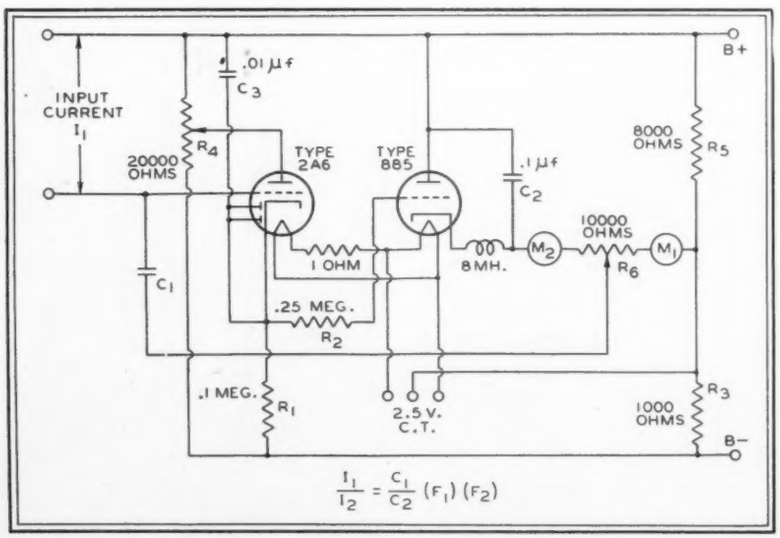
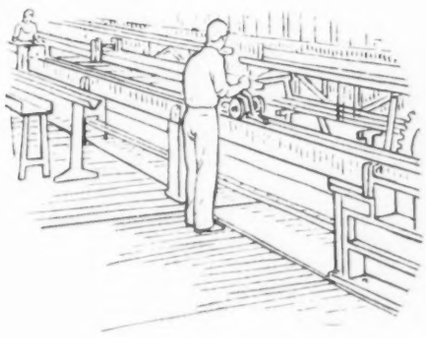


Fig. 1. Circuit for Mr. Shepard's direct current multiplier

Capacity Operated A-C Relay

ANOTHER of Mr. Shepard's circuits is in Fig. 2 which shows a new and simple form of capacity operated relay that can be made up cheaply from standard radio parts. In this a-c circuit, the sensitive element is a pentode oscillator, the feed back of which is determined by the difference in the ratio between the inductances of the two parts of the oscillator and the ratio between C_1 and the antenna to ground capacity. The intensity of oscillation varies with a change of C_1 or a change in the antenna to ground capacity C_2. As the cathode of the oscillator is at an r-f potential, and as the control grid of the output tube is bypassed for high frequencies to the cathode, a negative d-c voltage equal to the peak r-f voltage on the cathode of the 6J7 will be across the grid leak and condenser due to the rectifying action of the grid of



WHAT IS LEISURE WORTH?

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Leisure time is the hand-maiden of efficiency. In this plant you'll find no machines to count the number of turns, the units dropping into a hopper, or some other check of the day's run.

We believe in time out to think about quality. We know our staff is more efficient because it is not driven by a stop-watch.

We do not talk in 1920 or 1929 terms. Our team is a bit over one year old. There are no cobwebs in our attic.

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MANUFACTURERS OF
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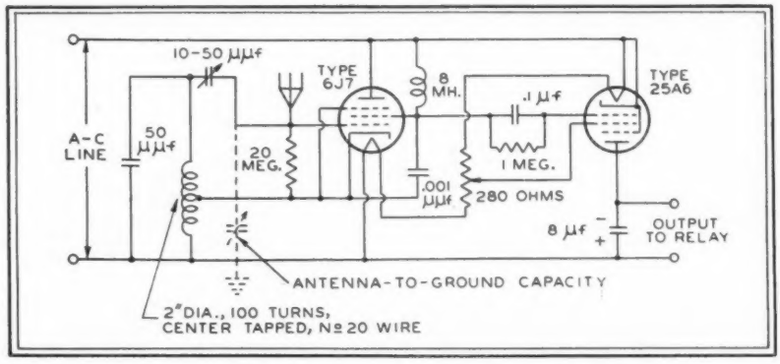

Fig. 2. A capacity operated relay made from cheap parts

the 25A6 and will thus appear on the grid of the 25A6. The 6J7 oscillates at high frequency on one half of the a-c cycle and builds up this negative charge on the grid of the output tube. During this time the output tube has negative plate voltage and is non-conducting. On the other half of the a-c cycle the 6J7 oscillator has negative plate voltage and so ceases oscillating. The negative charge built upon the grid of the output tube does not have time to leak off during this interval and hence is effective in controlling the plate current of the output tube, the plate voltage of which is positive during this interval.

This type of circuit finds its application in connection with door openers, counters, etc. and has even been used as a foul line indicator for bowling alleys.

Two Stage A.C. Operated Photo Relay

FIGURE 3 shows a simple two stage photo-amplifier relay circuit operating directly on the a-c line and made up only of one voltage divider resistor, one plate load resistor and three condensers. The circuit consists of a high impedance phototube feeding through a voltage amplifier or buffer stage into a power output stage. The filament voltage of the buffer stage has been reduced to reduce the temperature of and hence the electron emission from the grid. The plate current of the buffer stage is kept at a minimum to reduce the electron bombardment of the gas molecules within the tube and hence the gas current to the grid. The bias to the grid of the buffer stage is obtained by grid rectification. This method of obtaining the grid bias keeps the effective bias or plate current of the tube constant regardless of large fluctuations in contact potential between the grid and the cathode. The impedance of C_1 acts as a load impedance for the phototube, i.e., C_1 is charged up to a definite negative potential on one half of the a-c cycle and is allowed to discharge through the phototube on the other half of the cycle. The amount that is discharged by the phototube determines the working potential on the grid of the buffer stage. C_1 can be set to any desired value to control the desired sensitivity range of the relay.

As the 6J7 conducts on only one half of the a-c cycle it acts as a rectifier and so a negative d-c potential is built up on its plate. This negative d-c potential is suitable for use as bias and signal for the output stage. The plate of the 6J7 is returned through its load to a point on the voltage divider (one side of the heater of the 25A6) so that it will not be necessary for the 6J7 to be cut off to obtain a zero working bias on the grid of the 25A6 output tube. This allows the 6J7 to be operated about the center of its characteristic. As the output of the 6J7 buffer stage has relatively low impedance it is suitable for driving the grid of the 25A6 output stage, which in turn is capable of handling relatively large amounts of power to operate a relay.

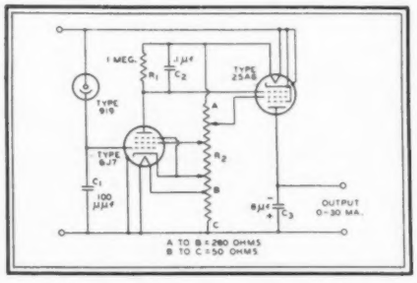

Fig. 3. Two stage photo relay

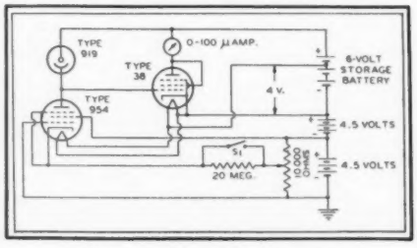

Fig. 4. Simplelight meter

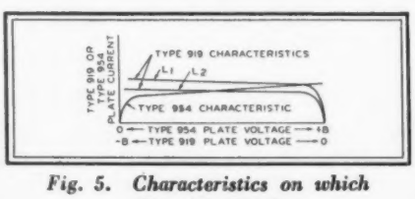
TYPE 919 OR TYPE 954 PLATE CURRENT
TYPE 919 CHARACTERISTICS
L1
L2
TYPE 954 CHARACTERISTIC
0 ← TYPE 954 PLATE VOLTAGE → +B
-B ← TYPE 919 PLATE VOLTAGE → 0

Fig. 5. Characteristics on which Fig. 4 is based

This circuit finds its principal use in applications where relatively small amounts of light are available and where light variations last not less than one tenth of a second.

Sensitive Light Intensity Indicator

FIGURE 4 shows a sensitive photo-amplifier circuit that can be used for accurately matching the intensities of amounts of light. With this circuit it is possible to indicate light differences or changes which may amount to small parts of one per cent. In this circuit arrangement the high impedance 954 pentode acts as a load impedance for the 919 high impedance vacuum type phototube. It can be seen by reference to Fig. 5 that the potential of the common connection between the 919 and the 954 is determined by the intersection of the 954 and 919 characteristics. It is also evident that a small change of light on the phototube will result in an output of several volts. This output voltage is applied to the grid of a 38 output tube the plate current of which is indicated on a 200 microampere meter. As the phototube with the 954 load has an extremely high output impedance it is necessary to operate the 38 so that its grid input impedance is extremely high. To reduce the grid emission to a minimum, the voltage to the heaters of the 38 and the 954 is reduced to 4 volts.

The possibility of emission from the heaters to the grid is eliminated by operating the heaters at a potential positive with respect to the plate of the 954 and the grid of the 38. Gas current to the grid of the 38 is kept at a minimum by keeping the potentials within the 38 low to minimize the ionization of any gas that may be in the tube. As all of the high impedance external connections are made to electrodes brought out to the tops of the tubes external leakages are reduced to a minimum. External leakage can be greatly reduced by carefully cleaning the tubes and coating them with a non-hygroscopic wax. This can be done by dipping the tubes in hot ceresin wax and holding them under the surface of the wax until the greater part of the moisture on the glass is boiled off. Care should be taken not to scorch the wax. Ceresin wax has long been used by research men for reducing the effects of moisture on leakages in high impedance d-c circuits. Dr. H. C. Rentschler of Westinghouse Lamp Company has very kindly made available the information on the use of ceresin wax.

Variable Range Light Variation Indicator

A PHOTO-AMPLIFIER such as the following finds its application as a densitometer for use in connection with the analysis of photographically recorded spectrums, or for use in connection with a suitable monochrometer or light

"2 to 4 Times" Better *Low-loss Material...*

A LONG-STANDING difficulty in designing high-frequency instruments has been to obtain an insulating material combining the necessary electrical characteristics with highly desirable mechanical properties. Today, this, and a growing number of similar problems, are finding complete solution in special low-loss Bakelite Molded materials.

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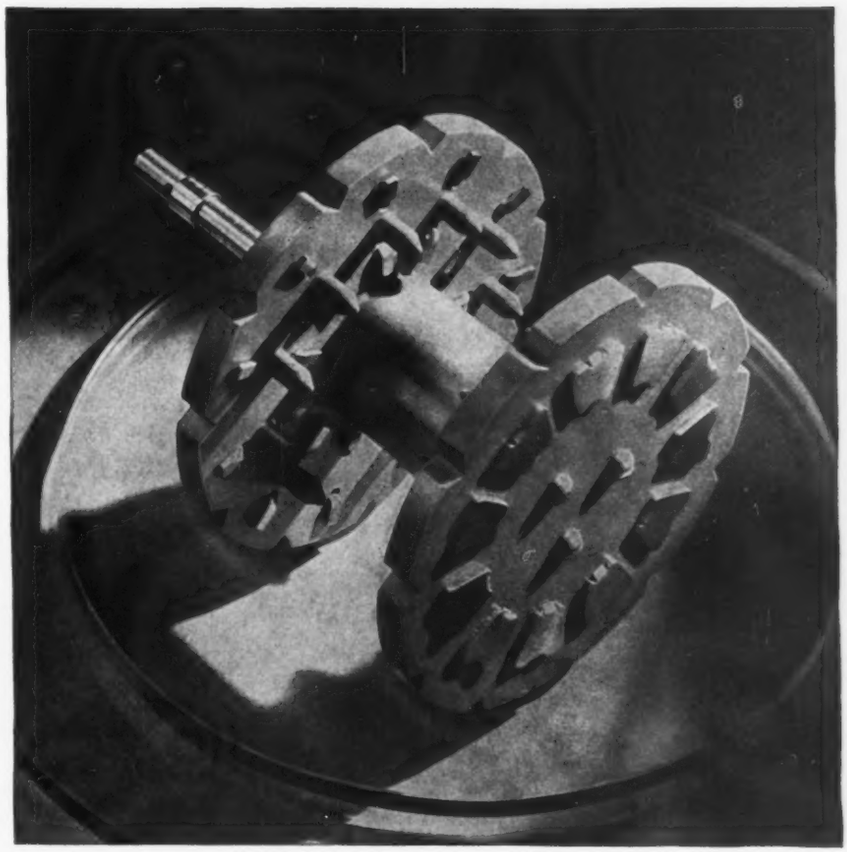

In addition to low power factors practically unaffected by 24-hour water immersion, low-loss Bakelite Molded provides the same desirable strength, toughness, permanent accuracy of form and dimension, and resistance to moisture, wear, heat and oil that standard Bakelite Materials possess. Its high volume-resistivity decreases less with rising temperatures than that of other materials commonly employed.

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(Top) Durable, permanently accurate drum of low-loss Bakelite Molded employed in Leeds & Northrup high frequency resistance boxes. (Left) Assembly of 6-drum L. & N. instrument showing resistors and drums in place.

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filter as a means of measuring the absorption lines or the concentration of certain chemicals in solution. These are only two of a large number of possible applications for this type of circuit.

It is sometimes desirable to reduce the sensitivity of Fig. 4 to small percentage changes of light. This can be done to any desired degree by varying

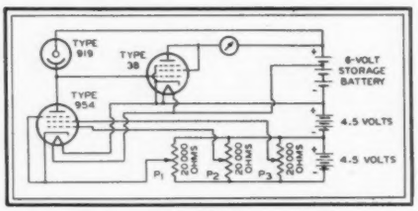


Fig. 6. Variable sensitivity light indicator

the plate characteristics of the 954 between that of a pentode and that of a triode. This can be done in the arrangement shown in Fig. 6, by properly adjusting P_2 and P_3 to control the relative potentials on the control and screen grids. When the No. 2 grid of the 954 is positive with respect to the cathode, the 954 has a high impedance pentode characteristic and changing the No. 1 grid bias changes the height of the characteristic, as shown in Fig. 7 by the curves No. 1 and No. 2. As the potential of the No. 2 grid is made more negative the characteristic of the 954 changes to that shown by curve No. 3. With zero bias on the No. 1 and the No. 2 grids the characteristic curve is as shown by curve No. 4. When a negative bias is placed on the No. 2 grid the shape of the characteristic is unchanged but it is shifted along the voltage axis as shown by curve No. 5. If the No. 1 grid is biased positively the slope of the characteristic is increased, curve No. 6 shows the effect of positive bias on the No. 1 grid (bias on the No. 2 grid for this curve is zero). Placing a negative bias on the No. 2 grid shifts this characteristic along the axis as shown by curve No. 7.

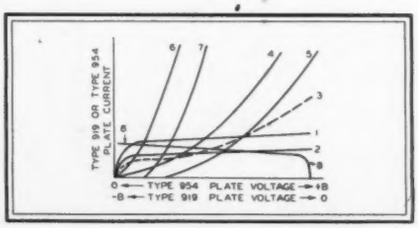


Fig. 7. Variation of sensitivity of Fig. 6

Thus the 954 phototube load can be adjusted to give practically any desired positive impedance load at any desired current and at any desired voltage across the tube. The full scale reading of the output meter can be made to cover a fraction of a per cent light variation, a 100 per cent light variation or any desired amount between these two extremes.

Cathode Ray Tube Applications

THE FOLLOWING material is due to H. J. Schrader of RCA Victor, and is a condensed version of his paper delivered at the I.R.E. annual convention in Cleveland, May 1936.

Using a standard 3-inch oscillograph, Mr. Schrader described how it may be applied to the measurement of vibration, for torsional measurements and strains and to the measurements of engine pressures. The intermediate apparatus which translates the mechanical variation into electrical currents or voltages is the Rochelle salt crystal which, as is well known, is strongly piezo-electric. Through cooperation with the Brush Development Company, in Cleveland, RCA Victor has developed a vibration pickup unit useful for mechanical vibration study.

For example, the measurements of torque twist and torsional vibration of shafts is a problem to which the oscillograph may be readily adapted. For these measurements, two eddy current alternators are mounted, one on each end of the shaft to be studied. The output of one alternator is connected to the vertical deflection amplifier of the oscillograph and the other to the horizontal deflection amplifiers. The figure which will appear on the screen when the shaft is rotated will indicate the phase relationship of the two alternators.

The shaft is first run with no load applied and the stator of one of the alternators shifted until the two voltages are in phase as indicated by a diagonal straight line on the screen. If a load is then applied the shaft will twist, causing the voltages from the two alternators to become out of phase, and the pattern will be an ellipse or a circle. The stator of one of the alternators may then be shifted until the pattern again becomes a straight line. The angular shift required is the angle of torque twist of the shaft. The accuracy of this measurement may be made as great as desired by designing the alternators with a large number of poles.

If torsional vibration is occurring the pattern on the screen will vary rapidly in shape and form a bright circular or elliptical spot. If now the alternator stator is shifted, two positions will be found where the pattern will open up in the center and a dark line appear. The angle between these two positions is the total angle of torsional vibration.

To measure the frequency of this vibration the two alternators are connected in series and the resultant voltage applied to the vertical deflection amplifier. Either the timing axis oscillator of the oscillograph or a beat frequency oscillator may be used to supply the horizontal deflection. The alternator stator should be set for average in-phase position and the pattern will then be that of a modulated wave. The envelope of this pattern represents the frequency of the torsional vibration and may be measured by either calibrating the timing axis oscillator or if the beat frequency oscillator is used may be read directly.

Torsional measurements made in the manner described are both rapid and accurate. The alternator rotor, being made of aluminum, adds little to the weight of the shafts being measured and so do not appreciably affect their performance. Very little power is required to drive the alternators so if they are made an appropriate mechanical size they may be applied to even very small rotating machinery.

Engine Pressure Diagrams

One of the most important applications found for the oscillograph is that of plotting engine pressure diagrams. Present methods, while very accurate at low speeds, become increasingly inaccurate at the higher engine speeds and are not usually usable above 3,500 RPM. The cathode ray oscillograph equipment designed for this use is not accurate at speeds below 1,000 RPM but its upper limit of accuracy is well above 10,000 RPM and could readily be raised still higher if desired.

If a quartz crystal is properly cut with respect to its optical and electrical axes and pressure is applied to its two faces, a charge will appear on these faces. The amount of this charge is directly proportional to the pressure applied and will vary directly as the pressure varies.

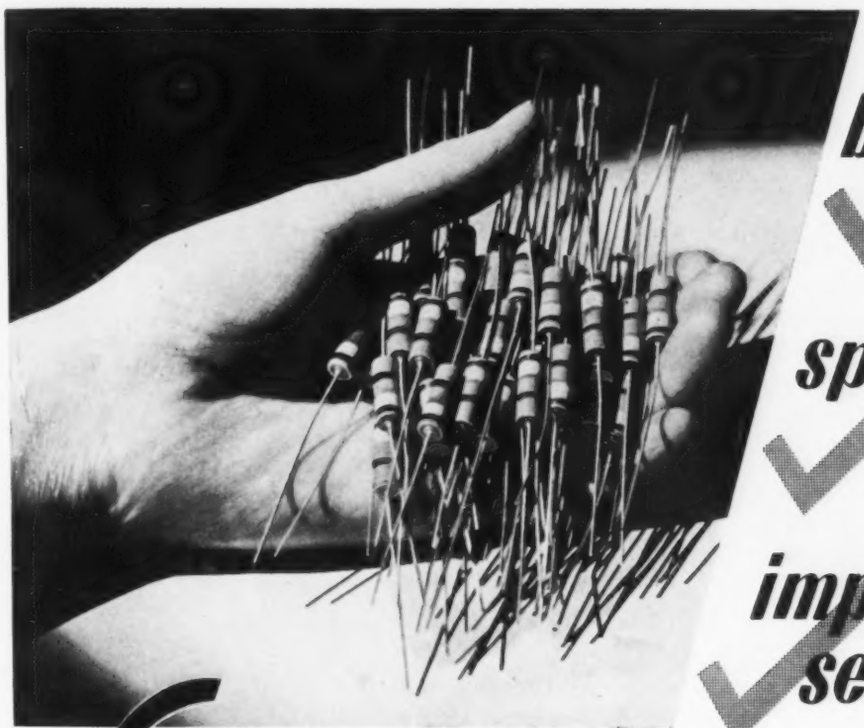
If no leakage exists the voltage difference between the two faces of the crystal will be inversely proportional to the capacity between them. This voltage may be applied to the grid of an amplifier and thus raised to the proper level to deflect the cathode ray beam. Because it is impossible to produce vacuum tubes with infinite input resistance, some leakage will always exist. To prevent errors from this source it is necessary to parallel the crystal capacity with a rather large external capacitor. This, of course, will decrease the sensitivity of the unit but by proper choice of condenser and tube input resistance practical values have been found which do not require excessive amplifier gains.

The pressure unit consists essentially of two quartz crystals mounted with their electrodes in a stainless steel tube. One end of this tube, sealed with a steel diaphragm, is introduced into the cylinder of which the pressure diagram is to be taken. The unit has been so designed that it may be screwed into the cylinder until the diaphragm is flush with the cylinder wall and the volumetric capacity of the cylinder thus remains unchanged.

The crystals are slightly tapered as used to prevent their high surfaces from grounding on the steel shell of the unit, thus no insulation other than that afforded by the crystals themselves is required and the insulation resistance of the unit is very high. The unit is

[*Continued on page 65*]

HERE'S THE SOLUTION TO :



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THE ELECTRON ART

EACH month the world's technical literature is scanned to see what physicists and engineers are doing with tubes, for presentation in tabloid form to Electronics' readers.

Modern Methods of Modulation

[J. LOEB, French Post Office]. Modulation is as a rule carried out in the last amplifying tube which, when acted upon by two separate waves, the carrier and the a-f wave, produces in the grid circuit or in the plate circuit an r-f wave whose otherwise constant amplitude C changes in the rhythm of the audio currents of amplitude A. The modulated wave owes its properties to non-linear relations in the grid or plate circuit.

The methods for producing the modulated wave are even more varied than the methods used for detection. A method extensively used in Germany is to add the a-f voltage over a transformer to the r-f voltage in the grid circuit (grid voltage modulation), the grid bias remaining constant and such as to cause either class A, B, or C amplification. Another method of grid circuit modulation is to use the a-f current supplied by a tube for varying the grid bias at a-f (grid d-c modulation), with or without adding an additional grid bias E for cutting off the plate current.

These two principles can also be applied, after the amplification of the r-f, to plate circuit modulation. Either the modulated wave is produced by superimposing upon the d-c plate voltage an alternating voltage that varies at the a-f to be transmitted, the actual voltage fluctuating about the average value. Providing that the tube be operated in a region of the I_p—E_p curve in which the voltage drop in the load is proportional to the plate voltage, the amplifier generates the desired modulated wave in the antenna. In the second method of plate circuit modulation the plate current is made to flow directly through the tube supply the a-f, and acting as a variable resistance, the a-f transformer being dispensed with. The cathode of this tube which acts as modulator must be able to stand high voltages.

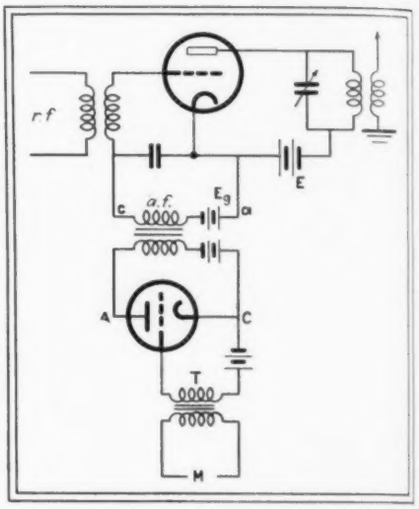
In grid circuit modulation the voltage E of the plate battery, and the load R in the tuned plate circuit remain at their constant value. In plate voltage modulation, the conditions in the grid circuit and the load R remain constant while E varies owing to the addition of the a-f voltage. A third possibility, therefore, is to keep grid and plate voltages constant, but to vary R by acting, for instance, upon the phase relations (Chereix modulation, used, for instance, by Radio-Paris, 75 kw. and Luxembourg, 150 kw.), or by using the variable resistance of a tube.

The plate current consists in every case of a d-c component I_0, and alternating components of amplitude I_1, I_2, etc., of a frequency equal to the audio wave supplied and possible higher harmonics. The d-c power supplied to the amplifying tube is equal to $W_0 = EI_0$; the a-c power which may be used for sending is equal to $W_1 = RI_1^2/2$ when higher overtones are disregarded, so that the efficiency is in the case of an unmodulated wave equal to

$$\frac{W_1}{W_0} = \frac{RI_1}{E} \times \frac{I_1}{2I_0}$$

The first factor in this product refers to the potential drop RI, and the voltage E of the source, with RI always smaller than E, in practice often not larger than $0.8E$. The second factor depends on the wave-shape of the plate current. When class B amplification is used, so that the operating point is near the lower bend of the I_p—E_g curve and the lower half of the wave is suppressed, $I_1/2I_0$ becomes equal to 3.14/4. As the grid bias is made more negative (class C) the d-c component decreases still farther, and $I_1/2I_0$ tends towards unity.

In the case of the modulated wave, the amplifier must remain in its class B, or C, even during the peak values during which the amplitude C is increased to $C(1 + K)$, where $K = A/C$,



Grid voltage modulation

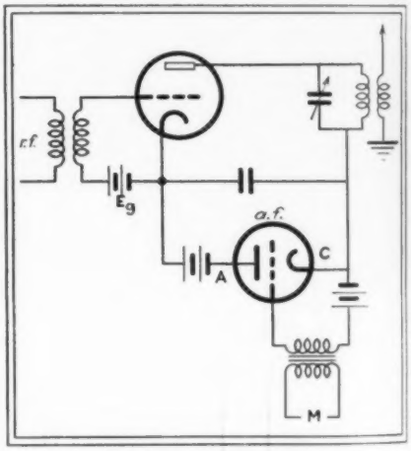


Plate current modulation

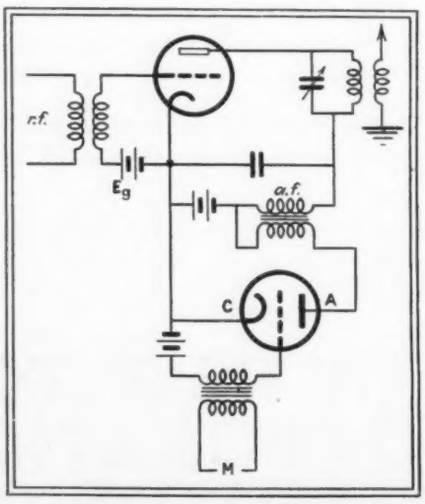
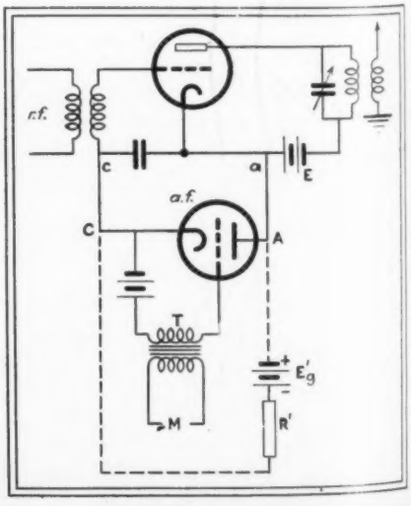
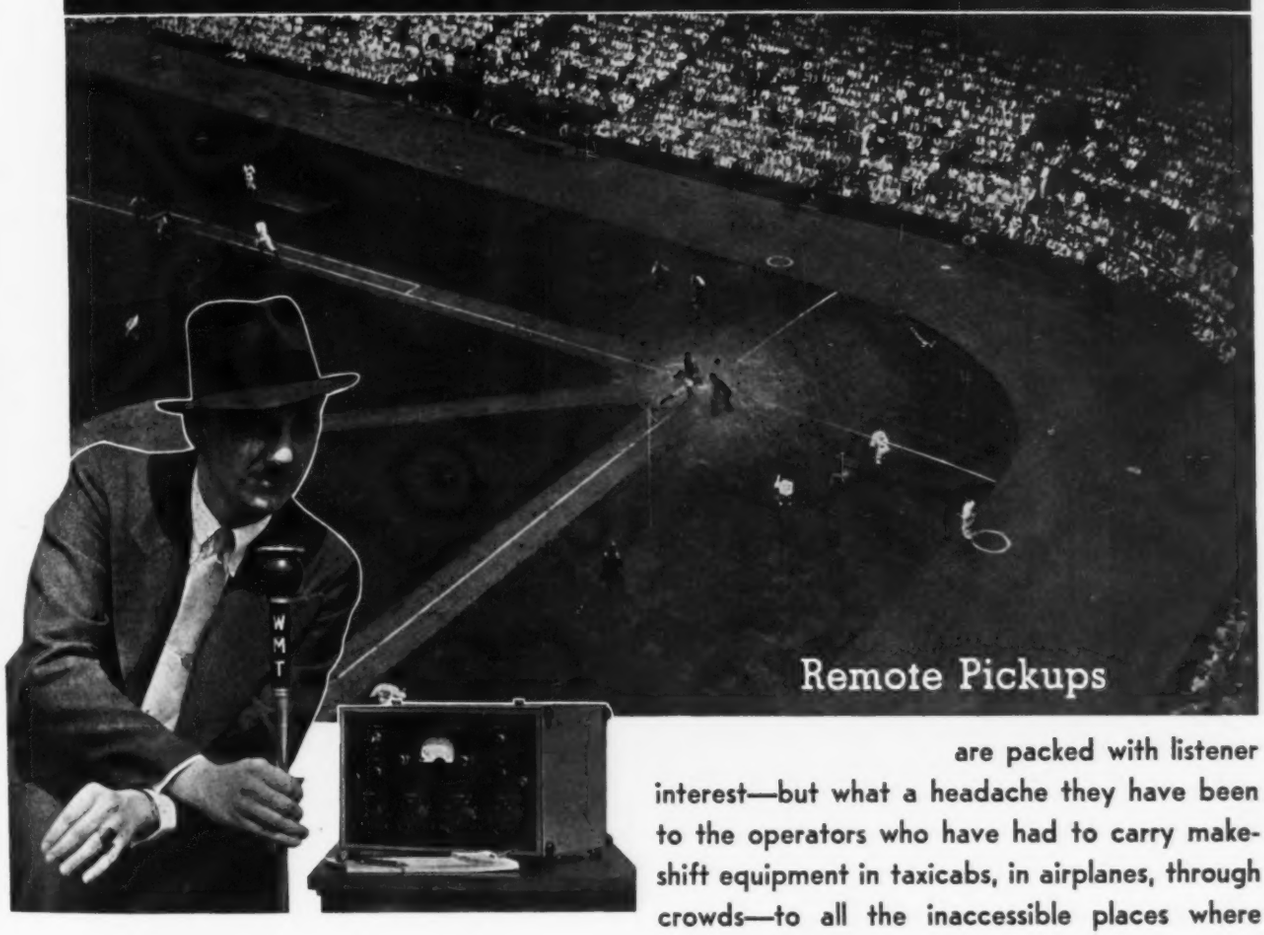


Plate voltage modulation

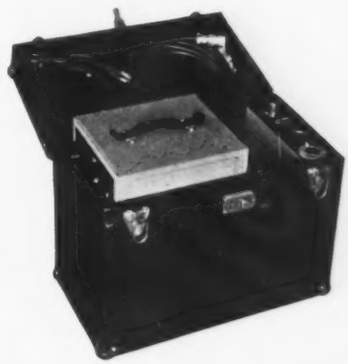


Grid bias modulation

TAKE YOUR STUDIO WITH YOU!



Remote Pickups are packed with listener interest—but what a headache they have been to the operators who have had to carry make-shift equipment in taxicabs, in airplanes, through crowds—to all the inaccessible places where news and sports events are happening.



Too often "remote control" has meant very little control at all over the quality of the broadcast that is put on the wire.

But now, after a year of development and proving in the field, the COLLINS 12X REMOTE AMPLIFIER is ready for your broadcasts. It is light, compact, will take severe punishment, and will give you remote broadcasts of studio quality.

The remarkable technical features of the 12X are explained in a descriptive folder—mailed on request.

COLLINS RADIO COMPANY

CEDAR RAPIDS, IOWA ★ NEW YORK, 11 West Forty-Second Street

that is, the efficiency of the carrier alone is reduced $(1 + K)$ times. When, for instance, $RI_1 = 0.8E$ at the most and class B amplification is resorted to, the maximum efficiency for the carrier is $0.8E/E$ by $\pi/4$, or 62.8 per cent; but when $K = 1$, this efficiency must be reduced to 31.4 per cent to preserve the character of the amplification. It is advisable to resort to class C amplification that gives a higher value of I_1/I_0, but introduces distortion, which requires correction either by increasing the intensity of the carrier in the peaks (Kraemer), or by multiple modulation stages (Société indépendante de T.S.F.).

In plate voltage modulation the value of RI_1 is proportional to E and RI_1/E = constant; this ratio may be made equal to unity. The factor $I_1/2I_0$ may also be given large values so that the efficiency based on the carrier is twice that obtained in grid circuit modulation. Against this gain, however, is the large amount of a-f power required, of the order of the r-f power. Since the a-f amplifiers must operate in class A they consume a large amount of power even in the absence of modulation. The waste in the absence of modulation may be prevented by using push-pull amplifiers.

The efficiency over long periods is poor because the amplifier must be designed to take care of the highest peaks although the highest a-f amplitudes last for very brief intervals only. The average degree of modulation may not exceed 20 per cent; the power contained in the side-bands is then 2 per cent of the carrier power. A more efficient system would be to maintain the percentage of modulation. In the case of grid circuit modulation a resistance is added in series between the transformer secondary and the ground; the rectified voltage drop in the resistor controls the grid bias in such a way that the r-f amplitude is large when the a-f amplitude is large. The detection introduces a delay which may be corrected by inserting a delaying circuit between the a-f source and the primary of the transformer. — *Onde electr.* 15:81-101, 142-149, 1936.

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Grid-bias Circuit

W. BRYAN SAVAGE of Stanmore, Middlesex, England, electronic engineer writes the Editors pointing out that the grid bias scheme to eliminate feedback troubles, page 42, March 1936 *Electronics* was devised by him independently and that articles on it appeared in the *Wireless Magazine*, September 1935, and in the *Wireless World*, January 3, 1936. He states that as a transformer manufacturer he finds it more convenient to tap the high voltage at the proper point and that a more expensive de-coupling arrangement is used.

"Onde Electrique"

BEGINNING WITH the January number, *Onde electrique* brings short summaries of recent German patents in the field of radio. The first three numbers of the year mention about 60 patents issued in 1935 and covering such items as variable coupling by Seibt, anti-fading, amplifier in which the coupling resistances are diodes, superregeneration, plate lead cooling pipes of sandstone or porcelain.

• • •

Non-radiating

THE TESTING LABORATORY of the Swiss Society of Electrical Engineers allows manufacturers to stamp a distinctive

mark upon electrical appliances which do not disturb radio reception under conditions laid down by the society.

• • •

Philips Technical Review

UNDER THIS NAME publications of the Philips research laboratory at Eindhoven are appearing monthly. The second number, February, has the following articles: Production of sharp fluorescent spots in cathode ray tubes, by G. P. Ittmann; Relaxation oscillators, by S. Gradstein; Optical model experiments for studying the acoustics of theaters, by R. Vermuelen and J. De Boer; A high-frequency furnace with valve generator, by G. Heller; Practical applications of X-rays for the examination of materials, Part 11 by W. G. Burgers.

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Volume Compressor

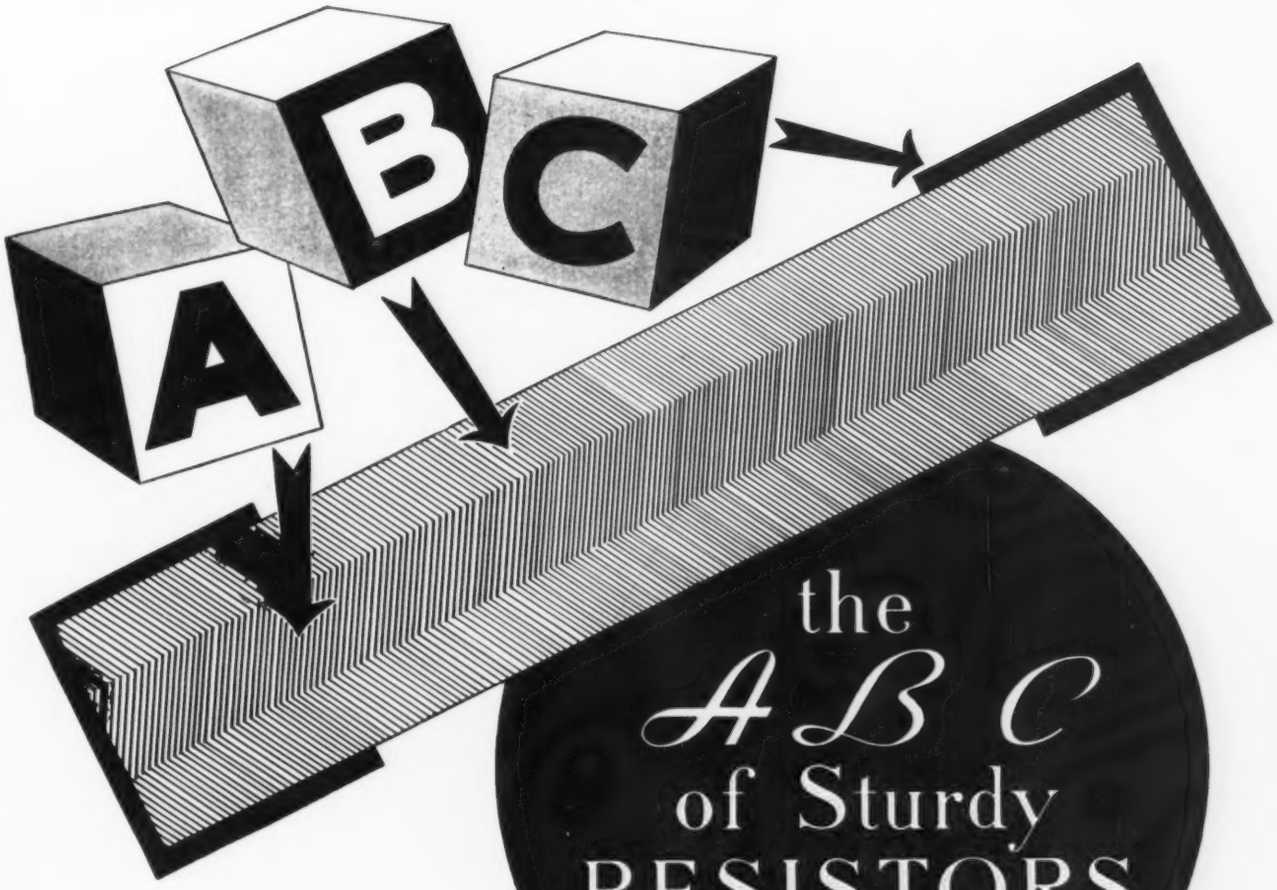
[*Continued from page 17*]

necessary for its cathode to be negative with respect to the anode. Since the output of the control voltage amplifier is connected to "*a*" it follows that no biasing potential will be placed on the grids of V_3 until the peak output voltage of the control voltage amplifier is greater than the value of positive potential between "*a*" and ground. No controlling action is introduced, therefore, until the energy level in the circuit exceeds an arbitrary value. The point at which control is introduced is determined by the adjustment of "*a*."

The time constant of the control circuit is such as to insure that the variation in the control-grid bias of V_3 is relatively gradual regardless of the input-voltage wave form. Two adjustments are used. When the two resistors R_{13} and R_{14} are connected in parallel, across C_{12} the action is rapid enough to allow the unit to be used as a volume compressor. That is, each volume surge is reduced in amplitude, as it occurs, and when it ends the unit restores to normal within approximately one second. This adjustment is desirable when the unit is used in connection with recordings or network programs that have previously been monitored. Using the unit in this manner permits the average percentage modulation of the transmitter to be increased without danger of overmodulation and without impairing noticeably the normal allowable artistic expression of the program. Where it is desired to use the unit as an automatic volume control the resistor R_{13}, only, is in parallel with C_{12}. This provides a more gradual change in volume and is especially desirable when broadcasting speech where it is important for the control not to restore between words. In this position it requires approximately five seconds for the unit to return to normal. The control will swing in within 0.2 second, however.

It has been found desirable to vary the input voltage to the control-voltage amplifier simultaneously with the time constant of the control circuit. This is accomplished by using a d-p-d-t. switch (S, S), as shown in Fig. 3. Throwing the switch to one position (*1*, *1*) provides the optimum adjustment when it is desired to use the unit as a volume compressor. The other position (*2*, *2*) allows the unit to be used as an automatic volume control on programs where manual control would be erratic.

The control has, thus far, been used as a separate unit in conjunction with a standard program amplifier. However, a better arrangement is to build the control unit as an integral part of the amplifier, since the optimum adjustments of the unit are more easily established and maintained in this manner. It is expected that such an amplifier will be in operation shortly.



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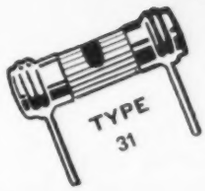
A. Center core of resistance material is surrounded by a dense shock-proof ceramic providing strength and protection against humidity.

B. Core and jacket are fired together at 2,500 degrees F. into a single, solid unit, hard and durable as stone.

C. Pure copper covers the resistor end for wire lead contact. Contact to the resistance material is at the extreme ends only, providing uniform resistance and Load distribution over *entire* length. End contacts do not short circuit part of resistance as in other types.



Since 1930 more than thirty-eight and a half million Centralab Fixed Resistors have been sold . . . and more and more set manufacturers are today specifying CENTRALAB for sturdy, dependable, trouble-free resistor performance. Their use extends throughout the entire spectrum of the electronic industry. In every need for Fixed Resistors . . . specify Centralab.

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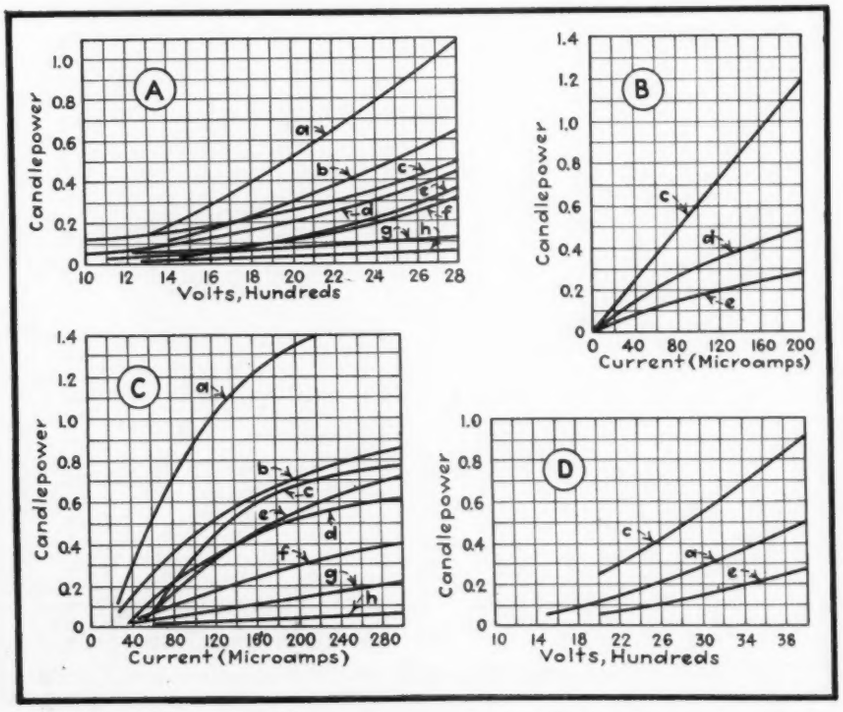
Fluorescent Screens for Cathode Ray Tubes

[LEONARD LEVY AND DONALD W. WEST] In a paper delivered before the Institution of Electrical Engineers on March 4 in London quantitative comparisons between several different types of luminescent substances used in cathode ray tubes were made. It was pointed out that fluorescent materials (those which cease to emit light immediately when the excitation from the electron beam is removed), and phosphorescent materials (those which continue to glow for some time after the excitation is removed) may be variously affected by the presence of impurities, some of which are undesirable because they reduce the luminous efficiency of the material, while others, such as nickel "killer" are used to improve the light output or to reduce the aftergow. For most purposes especially in television the afterglow is undesirable and therefore materials which are only slightly phosphorescent are most useful. In such substances the phosphorescence is of extremely short duration, not more than a few thousand micro-seconds. For example, calcium tungstate glows for 8 micro-seconds after the excitation is removed, cadmium tungstate for 8 micro-seconds, zinc phosphate for about 0.25 seconds, while zinc sulphide which has been treated with a nickel "killer" glows for only a small fraction of a micro-second (too small a time to be measured by the method used).

It was pointed out that the importance of maintaining the correct proportion and of eliminating undesirable impurities in the preparation of these substances often requires that they be prepared under "asceptic" conditions similar to those necessary in the field of medicine.

Five different types of material are mentioned as being suitable for practical applications in cathode ray tubes. The first, synthetic willemite, is an artificial zinc silicate which displays green fluorescence and some phosphorescence and which is especially sensitive to low-speed cathode rays corresponding to voltages of from 250 to 300 volts. Calcium tungstate produces a blue color which is highly desirable for photographic purposes. Cadmium tungstate is remarkable in that it produces a fluorescence of a pale blue color and is then therefore especially suitable for television pictures where a white and black image is desired, but requires high voltages to produce sufficient brilliance. Cadmium tungstate and calcium tungstate have been replaced by zinc compounds of higher efficiency in most cases. Zinc phosphate displays a red fluorescence, and because of its long phosphorescence after glow is of use in producing residual traces visible after the exciting beam has ceased to act. The most important types of material now used are several varieties of zinc sulphide and zinc cadmium sulphide, usually used in connection with a nickel "killer" which eliminates phosphorescence. As shown in the accompanying diagram the brilliance of these compounds for a given voltage is considerably greater than that obtainable with other materials. The paper also contains the discussion of light saturation in various materials, a phenomena which limits the amount of light obtainable from the compound regardless of the voltage or current used to produce it. (*Television and Shortwave World*, April 1936, page 241.)



Characteristics of fluorescent substances: (A) Output at constant current of 150 microamperes. (B) At constant voltage, 3,000 volts, by photoelectric method. (C) At constant voltage, 2,800 volts. (D) Photoelectric method, constant current of 100 microamperes. In each figure: (a) Zinc-sulphide, zinc-cadmium sulphide Z 23, (b) Zinc sulphide U 36, (c) Zinc sulphide G86, (d) Zn-Cd sulphide B 11, (e) Zn-Cd sulphide. (f) Willemite (g) Cadmium tungstate (h) Zinc phosphate

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Power-saving Tubes with Copper Cathodes

[FUNKTECHNISCHE MONATSHEFTE, January 1936, P. 9-11]. A number of new German auto radio tubes, series E, have just been developed. They differ from the standard C series only in their lower heater consumption.

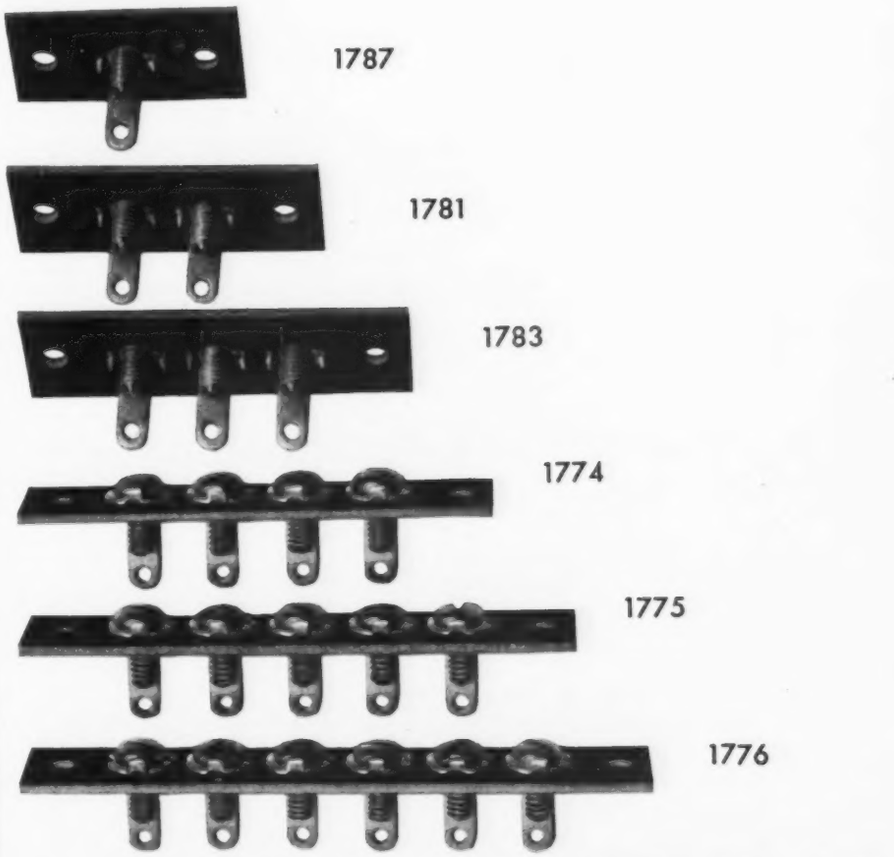
The heaters of the original E auto radio tubes consumed 2.6 watts. In the new tubes this figure has been reduced to as low as 1.5 watts by using copper for the cathode, instead of the customary nickel.

The change to this new cathode was decided upon as the most advantageous of three possible methods of reducing heater power consumption. Caesium had been considered first because of its low operating temperature (300°C), but its very short life made it, for the present at any rate, commercially unsuitable. While a reduction of the cathode size, and thus of its heater consumption, would have been comparatively simple, this would have upset the present standardization of German vacuum tube construction very seriously. The copper cathode however required no changes in tube construction, and the electrical characteristics of the new E tubes are, with a few minor exceptions, really identical with the type C series.

The radiation coefficient of copper under infra red rays was found to be approximately ⅓ that of nickel, and it was evident that so great a reduction of heat losses would considerably lower the power required by the heater element. The copper cathode readily suggests itself for larger tubes, where losses from heat radiation are an item. The same type of bifilar wound heater is used as for the nickel cathode.

It may be of interest that the new type E exponential pentode has a more favorable characteristic curve than the type C, and that there is less cross and hum modulation with the new tube. The final pentode is capable of delivering a speech output of 3.6 watts, with maximum distortion of 10%. The output of the new full wave rectifier is now 10 mA greater, namely 60 mA.

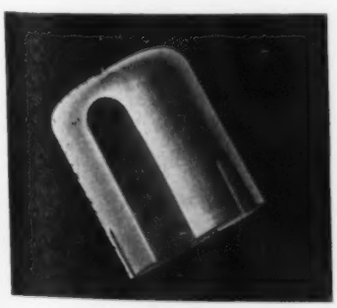
LET YOUR GUIDE IN BINDING POSTS BE



CINCH

From one to six—choose the one that fits your need! The "Cinch" Binding post you select is used by the most discriminating set manufacturers—everywhere. That is the most sincere endorsement. Supplied plain or with marking. By continued use the leading set manufacturers *recommend* "Cinch" parts.

Here is the CAP SHIELD. "CINCH" designed steel shield; sets snugly on tube top over screen grid cap. The perfect function of the tube is assured; hovering electrical interferences, or extraneous disturbances are grounded. Sharp indentations at base of shield, a feature, assure contact when shield is applied.



No. 6020
Recently introduced—already, a popular "Cinch" part.

CINCH MANUFACTURING CORPORATION
2335 West Van Buren Street, Chicago, Ill.
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MANUFACTURING REVIEW

Literature

✦ **Resistors.** International Resistance Company 401 N. Broad Street, Philadelphia, Pennsylvania, has a new spiral-bound catalog describing its complete line of fixed and variable resistors.

✦ **Amplifiers.** A new 48 page bulletin including data and circuits on amplifiers from one half watt to 1,000 watts output; chapters on audio transformer design; charts on decibel conversion; reactance data; published by United Transformer Corporation, 72 Spring Street, New York City.

✦ **Recording and transcription.** Presto Recording Corporation, 139 West 19th Street, New York City, has prepared a catalog describing in detail the latest developments in equipment, discs and parts, for instantaneous recording and transcription. Copies available upon request.

▶ **The Stupakoff Laboratories,** Pittsburgh, Pennsylvania, have recently published a small card on which are mounted various component parts used in metal tube manufacturing, consisting of ceramic insulators, insulated filament wires, Kovar eyelets, Kovar copper lead-in wires and exhaust tubes. Copies of this card may be secured by writing the Stupakoff organization.

✦ **Instruments.** G-M Laboratories, Inc., 1731 Belmont Ave., Chicago, Illinois, have published a new catalog of photoelectric units. The catalog describes electrical apparatus for measurements and control, and additional descriptive information on these units is available upon request.

✦ **Auto radio equipment.** F. W. Stewart Manufacturing Corporation, 340 W. Huron Street, Chicago, Illinois has issued a catalog describing their auto radio remote control equipment and parts for every make of car.

✦ **Tubes.** Federal Telegraph Company, 200 Mt. Pleasant Ave., Newark, N. J., has issued a new catalog giving ratings and data on Federal type vacuum tubes. Also additional data sheets on the Federal mercury vapor tube and thermionic rectifier tubes.

✦ **Speakers.** Catalog describing permanent magnet speakers for use in receiver, car and public address equipment, published by Cinaudagraph Corporation, Stamford, Connecticut.

✦ **P.A. amplifiers.** Wholesale Radio Service, 100 Sixth Avenue, New York City, has published a catalog describing the complete line of 1936 Lafayette public address amplifiers, systems and accessories. Copies may be obtained by request addressed to the above address.

✦ **Insulating varnish.** Literature on properties and applications of insulating varnish, published by Irvington Varnish & Insulator Co., Irvington, New Jersey.

New Products

Vacuum Gage

THE WINSLOW ENGINEERING COMPANY, Newark, New Jersey. Pirani type electric vacuum gage, just announced, is useful in any application where quick accurate determination of extremely low pressures are to be made. It uses a platinum alloy ribbon as filament rolled so as to have small cross sectional area to get quick cooling. A duplicate tube, open to the air, balances for atmospheric pressure and ambient temperature changes, is operated in the bridge circuit which contains the evacuated tube. Price, $75.00.

Oscillographs

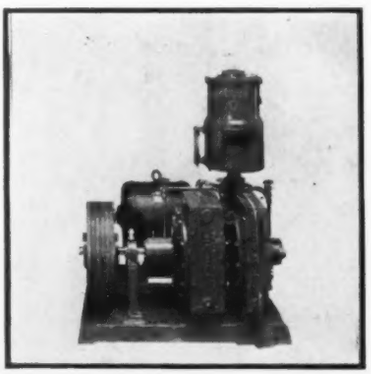
RCA PARTS DIVISION has announced two new types of oscillograph instruments: a model operating on 25-cycle a-c and a special "sweep" model with an oscillator which extends from 4 cycles to 18,000 cycles. The net price of each is $110.

D.C. to A.C.

CARTER MOTOR COMPANY, 369 Superior Street, Chicago announces a new converter to change d.c. (6, 12, 32 or 110 volts) to a.c. at 60 cycles, 40 watts. It is 4 inches wide by 5 inches long and 2¾ inches high and weighs 6¼ pounds.

High Vacuum Pump

BEACH-RUSS COMPANY, 50 Church St., New York, N. Y., offers a new two-stage integral type high vacuum pump for use in all high vacuum requirements such as neon signs, lamps, vacuum bottles, radio tubes and vacuum impregnating systems. It is built in any required metal to resist the corrosion characteristics of the impregnating compound, and is constructed without valves, gears or springs, so as to eliminate the principal trouble spot in vacuum impregnation. The pump is made for capacities of 8, 15, 30, 55, 100 and 200 cu.ft. per min. Larger pumps are made to meet special requirements.

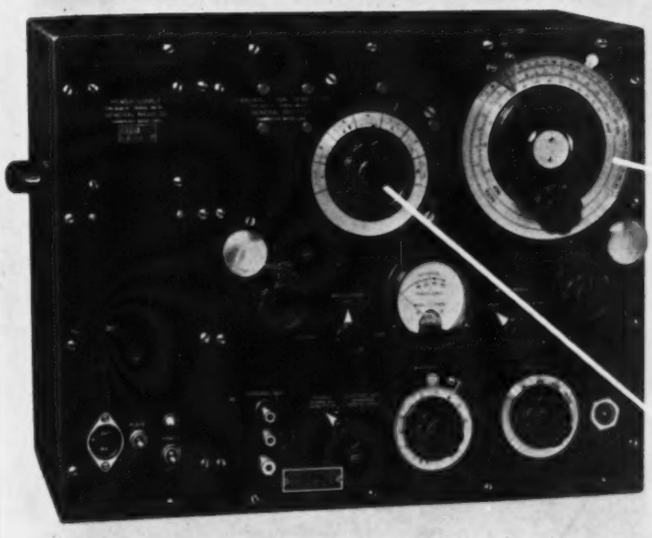


Wien Bridge

OUTSTANDING ADVANTAGES are claimed for the newest analyzer unit from Solar Manufacturing Corp., 599 Broadway, New York City. This is a capacitor-analyzer and resistance-bridge, to suit the needs of engineers as well as service men . . . a refined and extended Wien bridge built into instantly useful form for laboratory, shop and field work. All readings are secured direct from a color-coded panel, saving time and trouble formerly required in cross-referring to charts and graphs. This unit may be had in two models, both attractively housed in wood cabinets with detachable hinged covers. It is compact, light yet sturdy and thoroughly scientific.

Wattmeter

HICKOK ELECTRICAL INSTRUMENT COMPANY, 10514 Dupont Avenue, Cleveland, Ohio, is placing on the market a new electric appliance tester for use in testing radios, household motors, refrigerators, etc. This is a dynamometer type, available in watt ranges of 0-300, 0-750, 0-1,500 with 150 volt limit. Also available for 220 volt single phase and in higher watt ranges with external resistors. Uniform scale meter provides easy reading over the entire scale. Mounted on plastic base for portable use.



DIRECT READING
10 kc to 30 Mc

A NEW G-R STANDARD-SIGNAL GENERATOR

ANNOUNCED after several years of development—a moderately priced "all-wave" standard-signal generator with many mechanical and electrical improvements.

Simple to operate—accurately calibrated—thoroughly shielded—the new General Radio Type 605-A Standard-Signal Generator has all of the conveniences you have been asking for.

Check these features—see how closely they approach the ideal instrument.

- **DIRECT READING**—no calibration curves to read—no plug-in coils to change.
- **A-C OPERATED**—built-in voltage regulator—line voltage fluctuations have no effect upon frequency.
- **CONTINUOUS FREQUENCY RANGE**—10 kc to 30 Mc.
- **INTERNAL OR EXTERNAL MODULATION**—Internal fixed 400 cycle; external flat from 30 cycles to 15 kc. Both variable 0 to 50%.
- **NO FREQUENCY MODULATION.**
- **NO REACTION OF ATTENUATOR ON FREQUENCY.**
- **NO THERMOCOUPLES**—Vacuum-tube voltmeter indicates carrier amplitude—cannot be burned out.

PRICE: Type 605-A Standard Signal Generator: $415.00, Complete with accessories. Specify A-C or Battery Model.

WRITE FOR BULLETIN 16-E FOR COMPLETE DETAILS. Address General Radio Company, 30 State Street, Cambridge, Massachusetts.

SPECIFICATIONS

Circuit: Master-oscillator-amplifier. Frequency modulation and reaction of attenuator on carrier frequency reduced to negligible quantity.

Carrier Frequency: 10 kc to 30 Mc.

Frequency Calibration: Direct-reading to 1%. Straight-line logarithmic frequency scale.

Output Voltage Range: 0.5 microvolt to 0.1 volt.

Output System: 10-ohm constant resistive from 0 to 0.01 volt and constant 50-ohm from 0.01 to 0.1 volt.

Modulation: Continuously variable to 50%. Settings accurate to ±10%. Internal modulation 400 cycles, fixed. External modulation constant within 1 db from 30 cycles to 15 kc.

Stray Fields: Electrostatic and magnetic stray fields negligible.

Power Supply: Three a-c operated models available, for 60, 50 and 42 cycles. Built-in voltage regulator compensates for line voltage fluctuations between 100 and 130 volts.

Battery operation: Battery operated model available for 200 volt plate and 6.3 volt filament supplies. Control panel contains plate and filament meters and necessary controls.

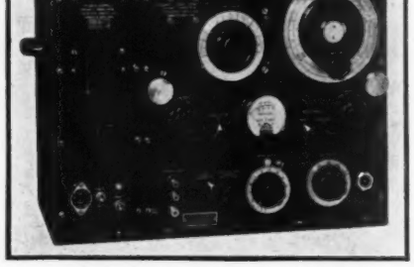
GENERAL RADIO COMPANY

Switch

YAXLEY, Indianapolis, has a fine looking brochure on their type 3,100 switch designed for short wave, tone control, and tap switch applications. It is small in size and yet has the same capacity as found in larger dimensioned units, has lower losses because of the reduction of material. The 3,100 switch incorporates a newly-designed indexing feature with positive action, separated from switch circuits.

Signal Generator

GENERAL RADIO, Cambridge, announce a new standard signal generator, model 605-A. It is a-c operated, with a built-in voltage regulator, is direct reading in frequency (no plug-in



coils), covers from 10 kc. to 30 mc. in 7 bands, has provision for external or internal modulation (internal — 400 cycles at 0 to 50 per cent; external 30 to 15,000 cycles up to 50%), no frequency modulation, no thermocouple to burn out. It lists at $415 complete.

Tone-bell Reproducer

CAPABLE OF PRODUCING a wide range of frequencies and designed to augment and strengthen all kinds of sound with complete distribution and without annoying projectional features, a low level tone-bell reproducer is accounting for much of the increased production of Fox Sound Equipment Corporation, Toledo, Ohio.

It is being used especially for inside installations or for use in small areas. The tone bell, constructed of special alloy aluminum, is claimed to be technically correct as to curve. It can be moved through 180 degrees in a longitudinal direction.

A unique mounting bracket is attached to the center of gravity, making directional adjustment perfectly stable. It can be secured on vertical or horizontal structures for permanent installation. The cradle is free to turn through a radius of 360 degrees. The sound chamber is equipped with the proper air by-pass for bass reproduction without distortion.

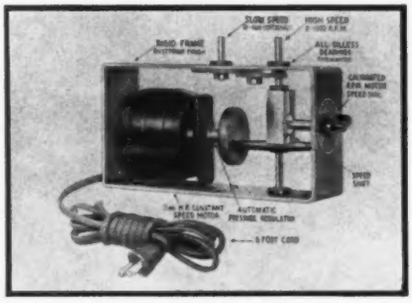
Communication System

COST TO business of communicating between different departments took a drastic drop with the announcement of a new, low-priced Intra-Department Communicating System by Bell Sound Systems, Inc., 61-63 East Goodale Street, Columbus, Ohio. Trade-named as Belfone this new equipment offers to even the smallest factories, offices, restaurants, and stores, the advantages of sound equipment previously considered a luxury available only to large concerns. (A two-way system costs as little as $39.50).

The system uses a transmitter approximately the size of the smallest midget radio. More than one loudspeaker can be used. Even though a person may be standing 25 or more feet from the receiver, his reply, in a normal voice, will be picked up and transmitted. By a combination of two or more of these small, compact units, very simply wired, a wide variation of systems can be accomplished. One station can talk to any one of a number of stations by means of a selector key. Also, with a multiple hook-up, there can be a number of simultaneous conversations.

Vari-speed Motor

CONSTANT SPEEDS with less than 1% drift, variable from 0 to 1,000 r.p.m. by turning a small calibrated dial are possible with the new Senco Vari-Speed Drive developed by the Sundt Engineering Company of Chicago, affiliate of Littelfuse Laboratories.

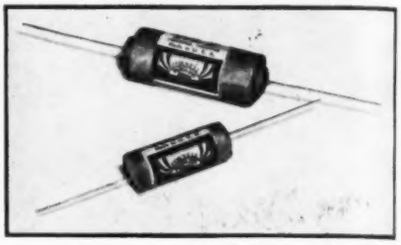


The unit is powered by a 1/100 hp. 110v shaded induction motor and the speed is changed by means of special wear resistant friction disc clutch. Oilless bearing are used throughout. The average torque is 1.0 inch pounds. A 10 to 1 reduction is available for slow speeds. Attractively finished, the unit measures only 8½x3½x4½ inches and weighs 10 pounds.

While this unit was designed primarily to provide a synchronous scanning system for use with the Senco Neon Oscilloscope Tube, it has many other shop and laboratory uses; sweeps for cathode ray tubes, stroboscope systems, timing and control devices, automatic switches, advertising displays and novelties, laboratory life tests, lecture room demonstrations, etc.

Tiger and Cub Condensers

CORNELL-DUBLIER announces two new lines of tubular condensers which are aimed at the solution of the humidity and high temperature problem as well as the desire for effective r-f and a-f by-passing. These lines are improved Tiger and Cub lines as offered heretofore. They have new wax poured ends



and outside wax dipping, they operate properly up to 185° F., retain their high internal resistance under high humidity operating conditions, and have other advantages especially important in new receivers.

Discs

UNIVERSAL MICROPHONE COMPANY, Inglewood, California, has announced an added process in the manufacture of its Silveroid recording discs. Each record is now treated individually with a preservative before shipment. The new treatment is said to prevent deterioration of coating due to temperature and various and sundry weather changes, especially in shipping to foreign countries, to be waterproof and not to show the effects of temperature or humidity, dry or moist climates.

After the disc has been treated and a recording made, it may again be treated by the operator to prevent any possible deterioration after it has been recorded upon. Universal Microphone will now market its professional recording machine with a new turntable. It is approximately twice the weight of the former one, and is mounted on ball bearings.

Set Analyzer

THE NEW MODEL 85 UNIMETER (Clough-Brengle Company, 1134 West Austin Ave., Chicago), features an improved five-inch fantype meter making possible a 50 to 100% increase in meter scale length. This point-to-point set analyzer and all-purpose component tester has d-c ranges of 0-15-150-750 volts and 0-1.5-15-150 ma; a-c ranges of 0-15-150-750 volts, ohms 100, 20,000 and 2 megs. All ranges are made instantly available at binding post terminals through a rotory selector switch.

The Model 85 is 8¼" high, 5¾" wide, and 4½" deep with self-contained batteries so small that it may be carried in a small tool case. Net price, complete with batteries, $24.95.

IRC Leadership is a living thing

. . . for IRC engineers are alive to the needs of the industry . . . and equally alive in meeting them with creative research and advanced developments as evidenced by the constant appearance of new products.

Leadership is reflected in the design, construction, quiet operation and superior performance of the IRC Type C Volume Control. It is equally apparent in the Type BT Insulated Metallized Resistor—an outstanding engineering development of IRC creative pioneering. You'll immediately recognize it in the IRC Type MW Wire-Wound Resistors—a radical departure from conventional design. You'll see the evidence of that leadership in IRC Type BW new Low Wattage Wire-Wound Resistors.

Space limitation prevents the listing of other IRC innovations. But IRC leadership knows no limitations.

Acquaint yourself with the full facts concerning IRC engineering achievements.

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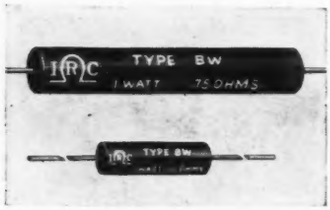
ITALY DENMARK AUSTRALIA

Wire-Wound Low-Ohmage Resistors

AN ECONOMICAL, completely insulated wire wound ½ and 1-watt resistor, similar in size and appearance to the well-known IRC Insulated Metallized units, has been announced by the International Resistance Company.

Thus an alternative to the usual carbon or metallized filament type resistor is now available in power ratings of ½ and 1-watt, and in resistance values of 0.25 to 500 ohms, and 0.5 to 2,000 ohms respectively, with respective lengths of ⅝ in. and 1½ in. Completely insulated against short circuits or grounds and against the effects of humidity, Type "BW" consists of wire wound on a textile core of small diameter, to which wire leads are clamped under pressure for permanent contact, molded at high pressure in a special phenolic compound of excellent properties.



This method of assembly insures low noise levels and permanent contact. The result, the manufacturers state, is a stable, conservatively-rated, small, insulated wire-wound resistor, having all the electrical characteristics and stability of its type, together with compactness and complete protection against abnormal atmospheric conditions.

Tuner-Amplifier

THE NEW ACRATEST 15 Watt Combination, recently announced by Federated Purchaser, Inc. of 25 Park Place, New York City is a complete entertainment unit of fidelity.

The Tuner portion uses four all-metal tubes in a super-heterodyne circuit, passing a band width of 7,500 cycles and with a sharp cutoff beyond this range.

The tuning indicator 6E5 is used, assuring accurate tuning on the center of the broadcast carrier for true studio reproduction. It also makes possible noiseless tuning. With the volume control set at a minimum position, stations can be tuned in using the visual method, without an audible signal. The audible volume is then advanced and reproduction obtained.

The amplifier portion using five glass tubes is designed for high quality reproduction. With a normal power of 15 watts and a peak power output of 24 watts, the gain at 1,000 cycles is 127 db making possible the use of crystal or velocity microphones on the high gain input.

Output ohmages are 2, 8, 12, 15 or 500 ohms for matching to voice coils of speakers or to a five hundred ohm

line. The 15 ohm output impedance may be used for direct coupling to a cutting head on recording equipment. A tone control is part of the circuit. The hum level, overall is minus 54 decibels below rated output.

The unit can be supplied in a louvred, ventilated crackle finished steel case with a hinged top, can be rack mounted or is supplied as a club model, together with an automatic record changer in a walnut console cabinet. The dimensions of the chassis are: 19x8¾x13¼ in. Dual d-c speakers in portable leather cases are also available, matching the output and field supply of the combination.

Armite

SPAULDING FIBRE, Tonawanda, N. Y., submits a sample of Armite, a granite color insulation material averaging well above the NEMA minimum dielectric strength requirements, with a Mullen bursting strength test of from 113 on 0.005 in. to 550 on 1/32 in. thick and of greater tensile strength than the standards NEMA requirements. It can be used anywhere that thin insulation, strength and toughness of structure are required.

Oscillograph

TRIUMPH MANUFACTURING COMPANY, 4017 West Lake Street, Chicago, displayed at the IRE Convention in Cleveland two measuring instruments of interest; a cathode ray oscillograph and a wobbulator to go with it. The generator covers the range from 100 kc. to 30 mc. directly calibrated on a large dial. The frequency modulated oscillator is swept over a 30 kc. band and is mixed with the master oscillator. The sweep has a pattern with two narrow vertical elements in it which act as beacons during tests. Both units operate from a.c. The oscillograph lists at $79.50 and the generator at $57.50.

A Eliminator

OBSERVING A LONG felt need by the trade for an auto radio "A" Battery Eliminator, the American Television & Radio Corporation of St. Paul, Minnesota, developed a unit specially designed for demonstrating and testing auto radio sets on regular a-c lines.

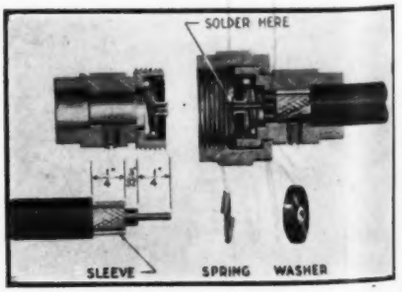
The new ATR unit is equipped with an on-off switch, pilot light indicator, 10 ampere fuse, rubber mounting feet, 6 foot all rubber cord set and is encased in an attractive heavy gauge metal black wrinkle finish cabinet. Dimensions are 7½ in. x 7½ in. x 5 in. and weighs 20 pounds for shipping.

It eliminates storage batteries and battery chargers; prevents the possibility of spoiling a sale because of a run down battery; operates the set at maximum efficiency at all times; delivers pure d-c at the correct voltages for the proper operation of any auto radio set; equipped with full-wave dry disc type rectifier assuring noiseless, interference—free operation and extreme long life and reliability; and is fully automatic and fool proof. Dealers' price is $12.95 complete; slightly higher west of the Rockies and in Canada.

Cable Connector

TO FILL THE NEED for a small positive and inexpensive cable connector, the Bruno Laboratories, Inc., 20 West 22nd Street, New York City, announce the Bruno Cable Connector, model CI. This is a small, all-metal coupling unit which permits instant connection or disconnection of two single conductor shielded cables.

Its contact points are positive in action, self-wiping, and maintained under extremely high pressures. Failure to hold contact is a practical impossibility. This makes the unit ideal for use where



dependability is essential, as in "Microphone to amplifier" circuits. The unit cannot be damaged by being stepped upon. It cannot be accidently disconnected. It is self-shielded and its diameter is only slightly greater than that of the cable, making its use inconspicuous.

The Bruno Cable Connector is finished in gunmetal and accommodates cables $\frac{5}{16}$" in diameter or less, and it is ⅝" in diameter and 1½" long. List price, $1.50 each.

Midget Transformers

NEW "MIDGET" audio-frequency transformers make possible the construction of extremely small-sized, light-weight amplifiers for aircraft and portable service. These transformers, a development of American Transformer Company, of Newark, New Jersey, have an average weight of only 3¼ ounces, operate at levels from —80 db to 0 db, are uniform within close limits from 20 to 20,000 cycles. Thirty-five standard designs are available in extruded aluminum cases of circular cross-section having a cubic content of 2¼ cubic inches.

They have a slight rising frequency characteristic at each end of the audio band. They are shielded electro-

magnetically with an insert of high-permeability alloy inside the aluminum case. A copper ground shield between the high- and low-impedance windings provides electro static shielding. Center-tap connections are taken from the exact electrical center of the winding. Windings are protected against corrosion.

In addition to Midget audio transformers, AmerTran also offer small size audio reactors, filter reactors, and plate-filament transformers. Midget Components are described in bulletin No. 1003.

Dial Material

CONTINENTAL DIAMOND FIBRE COMPANY, Newark, Delaware, has perfected a laminated synthetic resinous product known as Dilophane. This material has a tensile strength of 12,000 to 13,000 lb. per sq.in.; a compressive strength, flatwise, 34,000 to 56,000 lb. per sq.in.; and a flexural strength of 19,000 to 23,000 lb. The dielectric strength of the ⅛ in. Dilophane is 450 to 600 volts per mil. The power factor at 1,000 kc. is from 5.5 to 6 per cent and the dielectric constant at 1,000 kcs. from 5.75 to 6.25. This material is resistant to weak mineral acids and will dilute alkali, alcohol, benzol and other common organic solvents. Diolphane is especially recommended by the manufacturer for use on radio dials and instrument dials and other such places where stability to atmospheric changes in temperature and humidity are required.

Portable —not just moveable

thanks to AmerTran "Midget" Audio Components

Above: J. R. Poppele, technical supervisor, WOR Mutual Broadcasting System, holding small amplifier developed for use at the Democratic National Convention.

AmerTran Midget Audio Components make possible WOR's new microphone amplifier which is smaller than a telephone. Pertinent data-net gain 90 dB; frequency range 20 to 20,000 cycles; acorn tubes throughout.

Broadcast engineers have been quick to appreciate the advantages of AmerTran Midget Audio Components. They find these units ideally suited for many requirements—especially portable pre-amplifiers. They make possible the construction of better equipment combining small size and light weight with high gain and excellent frequency characteristics.

As an example, we illustrate WOR's new microphone pre-amplifier in which AmerTran Midgets and acorn tubes are used throughout. This unit weighs less than three pounds, measures only 4¾" by 3¾" by 2½", has a net gain of 90 dB, provides linear response from 20 to 20,000 cycles, and combines a 2-circuit mixer with a 3-stage a.f. amplifier. It is an entirely practical amplifier—not a toy—designed for outside pick-up service.

May we send you a copy of Bulletin No. 1003 describing AmerTran Midget Audio Components?

AMER TRAN

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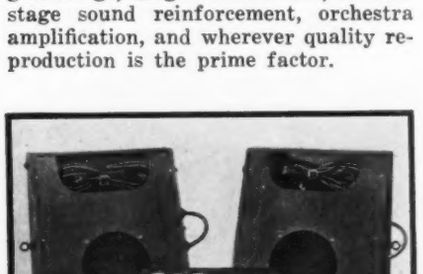
AMERICAN TRANSFORMER COMPANY

172 Emmet St. . . . . Newark, N. J.

Portable Public Address System

WITH ITS WEALTH of exclusive features and high power output, this Model 110-R portable public address system is designed for the larger types of portable installations such as outdoor gatherings, large auditoriums, theater stage sound reinforcement, orchestra amplification, and wherever quality reproduction is the prime factor.

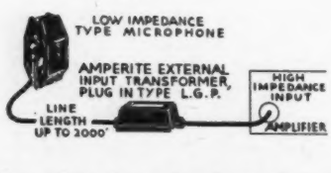


Model 110-R features dual speakers utilizing the latest Operadio development . . . the *Acousti-Reflex* principle. It comes with crystal contact type microphone with hanging fixture. The power output is 20 watts Class A. Microphone and phonograph inputs may be mixed. Tone control is provided for "shading" at the high and low end of the frequency spectrum.

It comes complete with microphone, microphone cord, speakers and speaker cords, tubes and carrying cases. Specifications and further details may be had by writing Operadio Manufacturing Company, St. Charles, Illinois, for Catalog 10-A.

Velocity Microphone

THE NEW DUAL IMPEDANCE microphone by Amperite, model RB-DI, can be used directly with either a high or low impedance input, accomplished without any loss in efficiency by using a specially designed transformer and a shielded four conductor microphone cable. The cable is terminated with a five prong female plug.


LOW IMPEDANCE TYPE MICROPHONE
AMPERITE EXTERNAL INPUT TRANSFORMER, PLUG IN TYPE L.G.P.
HIGH IMPEDANCE INPUT
LINE LENGTH UP TO 2000'
AMPLIFIER

The microphone is changed to 200 ohm or high impedance automatically by plugging in the proper male plug. By the use of this method, no undesirable dead windings are left in the microphone transformer. For only high impedance inputs, the standard high impedance microphone should be used. The dual impedance, however, is very useful when both low and high impedance inputs might be encountered. List Price $44.00. Complete with shock absorber.

Quartz Crystal Mounting

BLILEY ELECTRIC COMPANY, Union Station Building, Erie, Pennsylvania, has a new type quartz crystal mounting known as the BC46. This mounting consists of a thermal block, a bimetallic thermostat and a heating element all enclosed in an Isolantite shell. The thermal block serves as one crystal electrode which allows an efficient transfer of heat to the crystal. The position of the thermostat and heater has been determined to give maximum temperature stability from the standpoint of thermostat operation and freedom from serious changes in temperature as a result of heat cycles. This unit has been approved by the Federal Communications Commission for use in broadcast stations when used in conjunction with low temperature coefficient crystals.

Output Tube Tester

DEMANDS FOR COMPACTNESS in radio servicing equipment are answered by the Triplett Model 1501 multi-purpose power output tube tester which combines the equivalent of 10 separate units in one instrument. This addition to the Triplett line rejects any glass, glass-metal or metal tubes that will not perform in a radio receivig set. Tests tubes by amplification tests. Makes a

neon short test, separate diode test, metered paper condenser tests (for short and open), electrolytic condenser leakage test, d.c. voltmeter and milliammeter, ohmmeter, a.c. voltmeter, decibel meter—and impedance tests. The instrument is furnished in an attractive quartered oak case with sloping panels for either portable or counter use. Model 1501. List Price $70. The Triplett Electrical Instrument Company, Bluffton, Ohio.

Carbon Microphones

SHURE BROTHERS, 215 W. Huron St., Chicago, Illinois, have two new models of carbon microphones of the 2-button type. Model 3B is designed for spring suspension in standard carbon microphone rings. This unit has a rigid cast frame, 3 inches in diameter and a protective grill in front through which sound is admitted to the diaphragm. This unit weighs ½ lb. net and lists at $5.50. Model 10B is a convertible hand microphone which is designed to be adapted for stand mounting with string suspension by removing the head and inserting four hooks. This model weighs ¾ lb. net and lists at $10. Furnished complete with 6 ft. of 3 conductor cordage and 4 "quick away hooks" for stand mountings.

D.C.-A.C. Inverters

AMERICAN TELEVISION AND RADIO COMPANY, St. Paul, Minnesota, announce their 1936 line of inverters, calling attention to the following new features: Interference free, all-wave radio operation, long life vibrators, and four point voltage regulators. These inverters are manufactured in 16 different types

with or without built-in filter and are used in D.C. input voltage from 6 to 220 volts. They supply A.C. output voltages of 110 and 220 volts for the operation of standard 110 and 220 volt A.C. radio, public address systems, electrical testing equipment, and other electrical devices. Overall dimensions are approximately 7¾ in. x 8 in. x 3¾ in.

Triode

EITEL-MCCULLOUGH, INC., San Bruno, Calif., announce a new low-capacity high-mu general purpose triode. It has a 5 volt, 4 ampere filament, will dis-

sipate 35 watts on its tantalum anode, it is designed for r-f amplifier, doubler, oscillator and class B audio purposes. It is 5¼ inches high by 1¾ inches in diameter.

Television

[*Continued from page 30*]

them is negligible. The synchronizing circuits have been stabilized to the point where they are automatic in operation.

Necessity of Field Tests

All of the improvements outlined above have been made in laboratory set-ups, and the practical field experience with them is very limited. Before the system's suitability for a commercial service can be estimated, it is vitally necessary that the apparatus be given a field test under conditions closely approximating those which will be encountered in commercial service. The responsibility for this field test has been undertaken by the RCA organization, in which RCA Manufacturing Co., RCA Communications and the National Broadcasting Company, are cooperating.

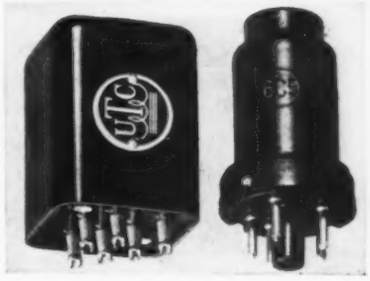
Briefly, the plan is this: A transmitter of 7.5 kw. power is being installed in the Empire State Building, and connected with a radiator especially designed to deliver low-angle radiation to the service area within a radius of about 30 miles. Television studios have been set up in the National Broadcasting Company (RCA Building, about 1 mile from the Empire State Building). Connecting the two buildings are to be two links, one a coaxial cable, the other a very high frequency above 170 mc.) radio link, which will feed the studio output to the transmitter. The dimensions of the system are 343 lines, 30 frames per second, two-to-one interlacing (odd-line type), a carrier frequency above 42 mc, but not yet specified exactly, with serrated pulse synchronizing signals. A limited number of receivers, not more than 100, will be installed in the homes of RCA technical personnel, within the service area.

This test, to begin on June 29, is purely experimental, although the conditions under which it is being carried out have been made to approximate those of a commercial service. Despite the opinion that workers in television know a great

Most Complete Transformer Line in the World

QUALITY·RELIABILITY

New... UTC ULTRA COMPACT Audio Units...



Designed as companion units for acorn and metal type vacuum tubes. They measure up to good broadcast standards, having a response plus or minus 2 DB from 30 cycles to 20,000 cycles. The average weight is 6½ ounces, and the overall dimensions are 1 7/16 x 1 7/16 x 1 13/16. These units are primarily intended for noise meter, aircraft and remote pickup work. Full descriptions of these units is contained in the new U1100D bulletin.

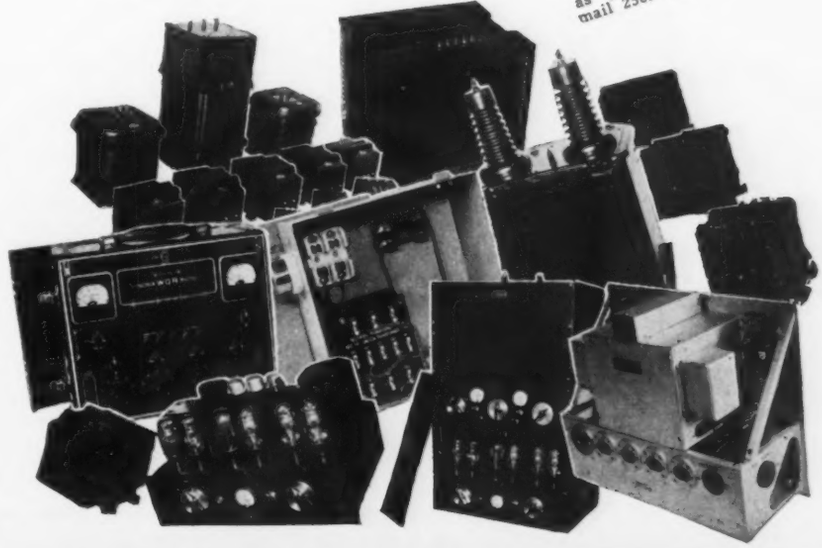
AUDIO, POWER AND FILTER EQUIPMENT

The units illustrated below are typical examples of the flexible manufacturing facilities of the UTC organization. In addition to the large number of standard items manufactured by UTC, many units are specially designed and produced to customers' specifications. Among the users of this service are such organizations as RCA, GE, Western Electric, Bell Telephone Labs, ERPI, and others of similar calibre.

Deliveries on special units can be taken care of quickly and prices are low. The UTC Research Laboratories and staff are at your disposal. We suggest you make use of them.

NOW READY

The new UTC Circular Slide Rule is being shipped with our 48 page Technical Bulletin. If you have not as yet ordered yours . . . mail 25c. NOW.



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GOAT

"Tailor-Made"
TUBE
SHIELDS

that
cost
less
than
cans

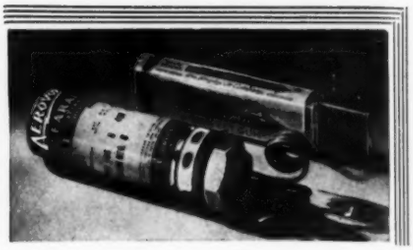
GOAT RADIO
TUBE PARTS,
INC.

314 DEAN STREET,
BROOKLYN,
N. Y.

deal more than they are admitting, very little is known about the propagation of a television signal in a service area. One of the primary objects of the test is, therefore, to determine the extent of the service area, and to map out the various percentages within that area which correspond to excellent, good, and fair service. The quantitative and qualitative effects of noise, both natural and man-made, must also be determined. Much of this work will be done with calibrated measuring equipment, on a strictly technical engineering basis, insofar as this is possible with existing methods.

But also the reaction of the listener-viewer, who has no measuring instruments and wants none, must be evaluated. In addition to the technical aspects of coverage, the performance of transmitting equipment and of the receivers, under continued service and under inexpert as well as expert handling, will be investigated. The third aspect of the test, which is only partially the concern of the technical man is the development of program technique. On the results of these tests the next move depends. If all of engineering objectives are realized, and if everybody is pleased with the results, then the problem of commercialization calls for the huge investment for transmitter and receiver manufacture.

RCA executives are inclined to take the view that haste must be made very slowly, because, as is readily apparent, television development is still in a state of flux. For one thing, before the RCA television test has begun, standards of television performance have been proposed which are still higher than those of the test. The 343-line, 30-frame figures for the field test were chosen, not as ultimate or standard values but as practicable for test purposes and sufficiently in advance of previous limits to reveal much-needed new information. The 440-450 line pictures now proposed look to the future. But they, and not the 343 line type, will be the basis of commercial service when it comes, if even higher standards are not proposed. At least 18 months will be necessary before knowledge is accumulated to resolve this difficulty; by that time the question of commercialization should be much easier to decide.



MIDGET CAN
Electrolytics

Ideal for crowded assemblies. Smaller cans . . . larger capacities. • Twice the capacity of former 1" dia. can units, for better filtering. Or height cut in half, for space saving. • Hermetically sealed for longest life. Inverted mounting. Color-coded leads • and so inexpensive.

Write for latest catalog covering complete line of condensers and resistors; also sample copy of monthly Research Worker.

AEROVOX
CORPORATION
75 Washington St. Brooklyn, N. Y.

Photo Electric Apparatus

These instruments incorporate the Lange supersensitive cells and are therefore suitable for high-accuracy as well as low intensities

Among the instruments are—
UNIVERSAL COLORIMETER for use with liquids, powders or solids.

ILLUMINATION METERS of various types — direct reading or recording.

PHOTOELECTRIC CELLS of highest sensitivity for photometric or colorimetric work.

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DESCRIPTIVE LITERATURE

PFALTZ & BAUER
INCORPORATED
Empire State Bldg. New York City

Tubes Make Autos

[*Continued from page 24*]

amplifier and associated electronic inspection equipment a system of filters was introduced, which passed only the band of frequencies which were produced by the part when struck like a bell.

At first it was thought that the filter system could accomplish the inspection because many of the castings with flaws or cracks produced lower frequencies than the good ones. Later in the experimental work it was found that some of the cracked castings produced frequencies very similar to the good ones. As a result, it was found necessary to introduce into this station a very accurate time delay.

As the good castings had a duration of audible frequency vibrations longer than the cracked casting, rejection of the unsuited parts, entirely automatic, was possible. The good castings were automatically indexed to the next station of inspection.

The measuring is accomplished mechanically. The results of the mechanical movement of the measuring arms is magnified by lever movement. The resulting lever movement closes contacts for sizes and rejections. Actually the contacts never "make" or "break" a circuit, because current is not allowed to pass through these contacts until they have closed; and then the current is removed from the complete circuit before the contacts open for location or indexing to the next article. This unique system results in indefinite life of the measuring contacts, and allows greater accuracy without frequent checking.

The photo-electric inspection for 1/32 inch pin holes follows the usual procedure of scanning the complete surface with a correctly designed optical system between the photocell and the article. It is rapid, and rejects many unsuited parts that the human eye would miss.

Many more interesting applications of the phototube and other electronic equipment for the automobile industry are now in the experimental laboratories, and will be ready in the near future. Some of these newer applications will startle the imagination of the better dreamers.

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PATENTS REVIEW

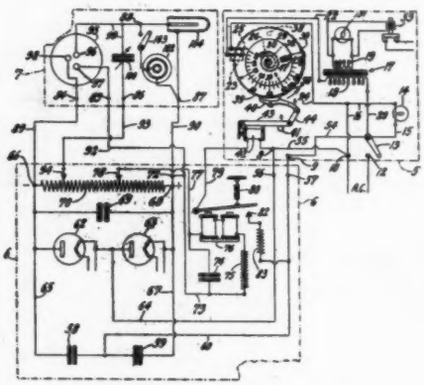
PATENTS indicate trends. Next year's radio circuits, applications of electron tubes for non-communication purposes, new tube types, new materials, may be discovered by following United States and British inventions.

Electron Tube Applications

Magnetic analysis. Use of a cathode ray oscillograph for indicating proportionately differences in permeabilities and in coercive force. K. L. Scott, W. E. Co. No. 2,035,248.

Stethoscope. A microphone followed by a three stage amplifier. Joseph Weinstein, Brooklyn, N. Y. No. 2,035,-034.

Dosimeter. Device for measuring applied dosage emanating from a source generating rays within the invisible portions of the spectrum, employing a condenser which is charged



to periodically cause the breakdown of a glow discharge tube. Arthur Mutscheller, Wappler Electric Co. No. 2,036,072.

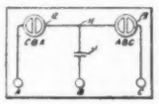
Photoelectric circuit. Combination of photo tube, amplifier, power supply, etc. A. J. McMaster and J. G. Wells, G-M Labs., Inc. No. 2,035,906 and 2,035,907.

Tube measuring equipment. Patents 2,031,923 to 2,031,926, inclusive, to E. L. Bowles, Watertown, Mass.

Burglar alarm system. Loud-speaking receiver having a diaphragm within a vault to be protected. R. V. L. Hartley, B. T. L., Inc. No. 2,031,951.

Magnetic measurement. Magnetic apparatus for measuring relatively small distances, for example the thickness of a non-magnetic coating on a magnetic base comprising a core, a probe of reduced cross-sectional area relative to the core, etc. Rolf Selquist, R. Overholt and J. H. Gordon, assigned Copperweld Steel Co. No. 2,033,654.

Phase-sequence indicator. A pair of neon discharge tubes and a condenser connected in Y, said tubes



having a critical voltage greater than $(\sqrt{3}-1)/2$ times the line voltage of the system. A. R. Hand, G.E. Co. No. 2,027,864.

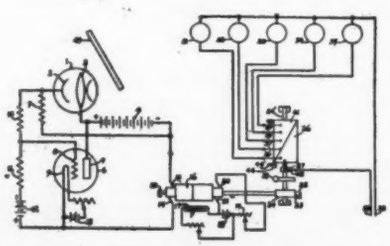
Electric clock. Use of a pendulum, triode, amplifier, etc. A. F. Poole, No. 2,033,899.

Depth measurement. An impact striker for generating a single sharp sound impulse, a receiver for receiving the sound after reflection from the object or surface whose depth is to be measured. E. E. Turner, Submarine Signal Co. No. 2,033,160.

Electrical measuring instrument. Vacuum tube in a bridge circuit supplied by a rectifier for measuring unknown resistances, etc. G. K. Graham, Oceanside, N. Y. No. 2,033,465.

Rotating machine control. Patent No. 2,031,942 to J. M. Duguid and J. H. Sole, B. T. L. and J. F. Kovalsky, Westinghouse E&M Co. No. 2,032,176.

Illumination control. Phototube system for maintaining the intensity of illumination constant over a predeter-



mined area notwithstanding wide variations in the uncontrolled components of the illumination. G. W. Calver, U. S. Navy. No. 2,030,854.

Power conversion. A. H. Mittag, No. 2,034,524, G.E. Co.

Electrical musical instrument. Patent No. 2,033,440 to Benjamin F. Miessner, Milburn, N. J., involving a combination of several tuned vibrators and mechanical coupling means engaging all of said vibrators and supported solely thereby. No. 2,017,542 and 2,035,238 to Nicholas Langer, Deep River, Conn., involving glow-discharge lamps, condensers, etc. No. 2,035,836 to R. H. Ranger, Newark, N. J., on a method of producing synthetic musical notes by supplying to a modulating electrical circuit in modulating relation oscillations of the frequency of the fundamental, etc., and other audio frequencies. No. 2,031,764 and 2,033,232 to Ivan Eremeeff, Philadelphia, Pa., on a photoelectric method.

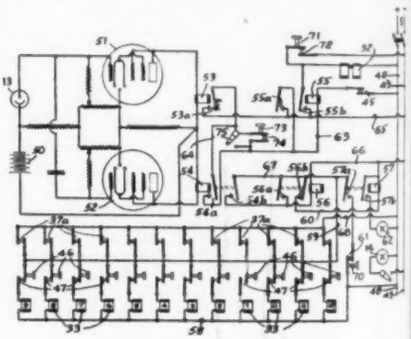
X-ray intensity meter. No. 2,037,-924. H. C. Rentschler.

Phase indicator. Stationary coil having a magnetizable core, a rotatable magnetic member, amplifier, synchronous motor, etc. W. A. Tolson, RCA. No. 2,036,444.

Resistance measurement. Use of an amplifier for measuring the resistance of the earth as a geophysical device. James Boyd, Denver, Colo., and B. Moritz, Chicago. No. 2,036,193.

Conversion system. Method of transmitting light variations by transmitting frequency variations. J. H. Hammond, Gloucester, Mass., No. 2,036,869.

Record verifying machine. Means including a light sensitive cell for sens-



ing the index point position in the column of a record card, an amplifier, etc. R. L. Palmer, International Business Machines Corp. No. 2,039,832.

Synchronizing system. Use of a vacuum tube amplifier with an a-c motor having electrically independent motor and generator coils. R. Adler, RCA. No. 2,039,869.

Anti-hunting system. In a positional control for heavy objects having means for producing and receiving a signal, a reversible power motor for driving the object, a tube circuit is used for controlling the motor as to torque and direction. F. L. Mosely, Sperry Gyroscope Co. No. 2,040,014.

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Electron Tube Applications

Vehicle lighting system. Use of a photo-tube of the current generating type, a relay, etc., for automatically turning on the lights of a parked car when the illumination falls below a predetermined limit. A. H. Lamb, Weston Corp. No. 2,039,230.

Metal gathering machine. Use of a photo-cell and amplifier with a means to condition the circuit for a current intensity of a predetermined effective value while a rod is at rest and in motion. W. H. Spire, Thompson Products, Inc. No. 2,037,604.

Volume control circuit. Circuit for providing feedback in a phonograph reproducer system. Herbert Lissauer, Telefunken. Berlin. No. 2,038,744.

Attenuator. A mixing system for phonograph pick-up, microphone, radio receiver, etc. A. R. Hopkins, RCA. No. 2,037,236.

Remote metering system. Method of producing at a distant point an indication of a quantity existing at some other point which consists in varying, at the point where the quantity is located and in accordance with the magnitude thereof, the amplitude of current received from the other point. E. I. Green, A.T.&T. Co. No. 2,039,404 and 2,039,405.

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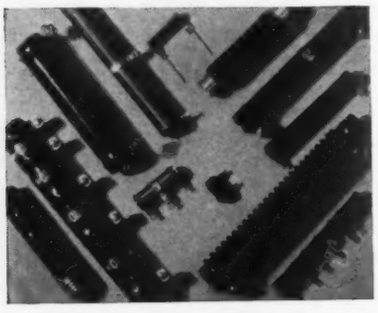

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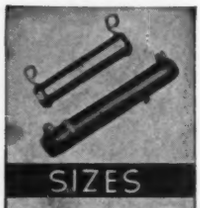

BULLETIN 11

Tells about Vitrohm Wire Wound Resistors, gives sizes, watt ratings.

BULLETIN 19

Describes Ward Leonard Ribflex Resistors for unusually heavy duties.

BULLETIN 25

Is a treatise of standard and special mountings and enclosures.

BULLETIN 22

Is about plaque type non-inductive and non-capacitive resistors.

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Amplifier Circuits

Direct coupled system. S. Y. White, RCA. No. 2,032,193.

Hum eliminator. Method of preventing interference in a tube amplifier from the fluctuating component of a uni-directional current by using resistance elements, at least one of which is comprised of a granular material having a hyperbolic resistance-ampere characteristic and having free carbon as an ingredient and means for holding the grains together under pressure. On the patent this material is labeled "Thyrite." R. A. Braden, RCA. No. 2,032,199.

Linear amplifier. In the anode circuit of an amplifier is placed a resistance element, which has a non-linear current voltage characteristic. Ordinarily the tube has a non-linear plate characteristic but when used with this material it assumes a linear characteristic. Irving Wolff, RCA. No. 2,017,192.

Band pass network. A pair of tuned circuits having a common capacitor and a bridging capacitor between the circuits being properly proportioned to provide a constant band width over a range of frequencies. John S. Low, AT&T Co. No. 2,018,140.

Gaseous tube amplifier. No. 2,017,-910, Michel Macksoud, The Electron Corp., East Orange, N. J.

Relay. An electrical polar relay for converting alternating current signal impulses into spaced direct current impulses. W. B. Wells, Pearl Harbor, Hawaii. No. 2,025,078.

Rectifier supply system. Two rectifier tubes and a pair of conductors connected to a source of a-c. The conductors are so interleaved that they produce a continuous electromagnetic field of the same polarity. August Hund, Wired Radio, Inc. No. 2,017,658.

Voltage control. An a-c generator, a glow tube across the output circuit of the generator, and means including a relay in series with the tube for varying the field strength of the generator. M. R. Miller, Associated Electric Laboratories, Inc. No. 2,035,613.

Short circuit detector. Circuit for detecting shorts in vacuum tube manufacture. H. P. Manly, Wilmette, Ill. No. 2,033,347.

Grid current compensation. An auxiliary tube connected between the grid and the cathode of a main amplifier tube, nullifying the effect of grid current. C. E. Fay, BTL, Inc. No. 2,033,278.

Multiplex transmission. No. 2,028,-805, R. H. Ranger, RCA.

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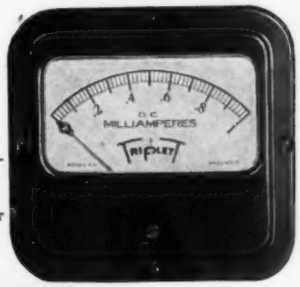

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Distortion compensator. In an amplifier an element in one of the circuits is traversed by currents depending upon distortion, and means for applying a potential having a definite relation to the flow of currents through this element, to a part of the system where it will compensate for the distortion. Hans Bartels, Telefunken, Germany. No. 2,035,289.

Selective circuits. An antenna coupling network operative over a band of frequencies. H. A. Wheeler, Hazeltine Corp. No. 2,026,075.

Push-pull amplifier. The control electrodes of this push-pull amplifier connected to the cathodes through a path of substantially low impedance to direct current whereby the control electrodes are at the same d-c potential as the cathodes throughout the operation of the stage. Means for coupling the source to the input electrodes of the push-pull tubes in such a manner that the potential level of the a-f energy is decreased to a predetermined lower potential level, said push-pull tubes being potential type, and operating as a class A amplifier. W. S. Barden, RCA. No. 2,017,199. See No. 2,023,506 to L. E. Barton, RCA.

Generator. A vibratory structure, for example, tuning fork, pick-up coils, etc. A. J. Williams, Leeds & Northrop Co. No. 2,034,787.

Frequency multiplier. Mendel Osnos, Telefunken, Germany. No. 2,013,806.

Key click filter. Reuben Lee, WE&M Co. No. 2,020,950

Single side band transmission. E. S. Purington, Gloucester, Mass. No. 2,020,327. A phase modulation system.

Rectifier control. Smoothly controlling the output of an arc rectifier having separate potential control of ignition time throughout its entire range from no current to full current by impressing on the ignition control constant alternating potential of the same frequency as the input power and lagging the same by 90 deg., and a controlling d-c potential for operation for said entire range. W. H. Howe, Atlantic Precision Instrument Co. No. 2,020,314.

Frequency stabilization. Patents No. 2,017,894, W. G. Cady, RCA; No. 2,017,712 to R. L. Downey, GE; and No. 2,019,765, Mendel Osnos, Telefunken.

Generator. A constant frequency oscillator. B. J. Witt, RCA. No. 2,034,735.

Detection. No. 2,022,412 to L. Egyed, Telefunken, Berlin. No. 2,019,503 to R. M. Page, Washington, D. C. No. 2,018,329 to Karl Steimel, Telefunken. on detector circuits.

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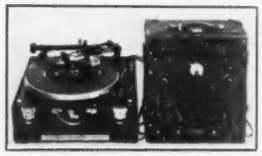

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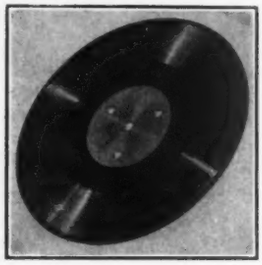

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Radiation suppressor. Use of a filter in the power transformer circuit. M. G. Clay, RCA. No. 2,039,634.

High frequency oscillator. Circuit for generating ultra high frequency electromagnetic wave comprised of a triode. Between the grid and the positive terminal of a battery connected to the cathode is a choke. In series with the anode is a second choke. Across the outer terminal of this choke and the cathode are a resistance and capacity in shunt. The plate is maintained negative with respect to the cathode. E. Fetterowsky and Heinz Lux, Telefunken. No. 2,031,101.

Multi-tube oscillator. A tube comprising six actual and one virtual element for generating beats. F. H. Engel, RCA. No. 2,031,100.

Crystal circuit. Circuit comprising several piezoelectric crystals which may be connected into the circuit by means of a switch. L. A. Gebhard, Wired Radio, Inc. No. 2,031,767.

Potential changer. Two patents. One to W. P. Lear, M. E. Nulsen and R. S. Yoder, P. R. Mallory & Co., No. 2,032,424. The other, R. J. Koegh, Chicago. No. 2,020,362, on means for deriving direct current of a given potential from a source of direct current of a different potential.

High frequency system. Two patents. N. E. Lindenblad, No. 2,027,919 and C. W. Hansell, No. 2,028,866, both to RCA on ultra short wave communication system.

Electron coupled oscillator. H. W. Parker, Rogers Radio Tubes, Ltd. No. 2,030,931.

Modulation Methods

Frequency modulation. The following three patents are devoted to this subject: No. 2,027,044, Rudolf Hofer and W. Kummerer, Telefunken, Berlin. No. 2,027,975 to C. W. Hansell, RCA. No. 2,032,403, M. G. Crosby, RCA.

Push-pull system. A pair of four-electrode tubes symmetrically arranged with symmetrical input circuit, an output including series capacities and inductance. Andre Cottet, Paris, France. No. 2,023,780.

Gaseous modulator. Use of a variable gas column associated with a crystal for modulation purposes. Mendel Osnos, Telefunken. No. 2,025,955.

Modulation method. Modulating in a low power high frequency carrier by a signal current, deforming a relatively high power low frequency carrier by the first modulated high frequency carrier. No. 2,026,005, George Wald, Mount Clemens, Mich.

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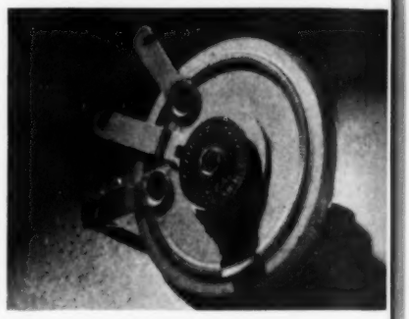

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Navigation Equipment

Direction finding apparatus. No. 2,026,123, B. L. Dolbear, RCA., No. 2,026,254, Mark Sandfort, Berkeley, Cal.; No. 2,018,357, J. H. Hammond, RCA; No. 2,017,909, August Leib, Telefunken; No. 2,019,403, W. S. Eaton, Los Angeles, Cal.; No. 2,026,359, D. W. Pickard, RCA; No. 2,017,908, August Leib, Telefunken; No. 2,027,529 and 2,027,530, J. H. Hammond, RCA, on a method of using television, facsimile, etc., for navigational guide purposes. No. 2,028,856 to Fred Woods, RCA.

Compass. Cathode ray type tube, the ray being deflected from the vertical by the earth's magnetic field. H. H. Engelhardt, Chicago. No. 2,025,580.

Patent Suits

1,558,437, I .Langmuir, Electrical discharge apparatus; 1,696,103, G. Seibt, Electric discharge tube; 1,748,026, L. E. Mitchell, Electron discharge device, D. C. N. J., Doc E 5171, *Radio Corp of America et al.* v. *Arcturus Radio Tube Co.* Dismissed Jan. 7, 1936.

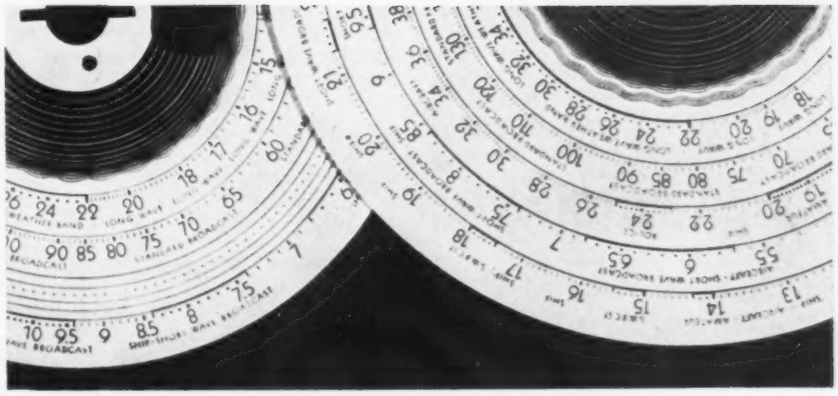
1,403,475, H. D. Arnold, Vacuum tube circuit; 1,403,932, R. H. Wilson, Electron discharge device; 1,507,016, L. de Forest, Radio signaling system; 1,507,-017, same, Wireless telegraph and telephone; 1,618,017, F. Lowenstein Wireless telegraph apparatus; 1,702,833, W. S. Lemmon, Electrical condenser; 1,811,095, H. J. Round, Thermionic amplifier and detector, D. C., S. D. Calif. (Los Angeles), Doc. E 528-C, *Radio Corp. of America et al.* v. *D. W. Smith* (*Westport Mfg. Co.*). Decree pro confesso for plaintiffs, holding patent valid, injunction granted Feb. 5, 1936.

1,354.939, H. D. Arnold, Vacuum tube device; 1,459,412, A. M. Nicolson, Thermionic translating device; 1,479,-778, H. J. Van der Bijl, Vacuum-tube device; 1,537,708, W. Schottky, Thermionic vacuum tube, D. C. N. J., Doc. E 5172, *Radio Corp. of America et al.* v. *Arcturus Radio Tube Co.* Dismissed Jan. 7, 1936.

1,297,188, I. Langmuir, System for amplifying variable currents; 1,573,-374, P. A. Chamberlain, Radio condenser, D. C., S. D. Calif. (Los Angeles), Doc. E 527-M, *Radio Corp. of America et al.* v. *D. W. Smith* (*Westport Mfg. Co.*). Decree pro confesso holding patents valid and infringed Feb. 5, 1936.

1,712,214, L. L. Jones, Tuned radio frequency amplifying system; 1,770,-524, same amplifying system, D. C., S. D. N. Y., Doc. E 57/100, *L. L. Jones et al.* v. *Radio Corp. of America.* Consent order dismissing cause without prejudice (notice Jan. 17, 1936).

1,714,191, 1,710,073, S. Ruben, Electrical condenser, filed Feb. 3, 1936, D. C., E. D. N. Y., Doc. E 7882, *Ruben Condenser Co. et al.* v. *Walgreen Co., Inc., et al.*



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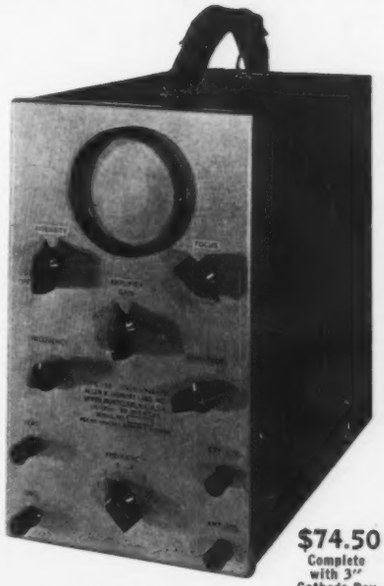
CONTROLS: All on front panel. Single knob control of signal input voltage, sweep frequency, amplitude and focusing.



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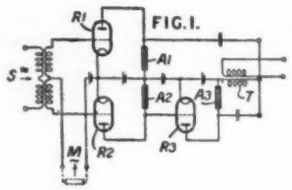
Modulating system. A modulating system particularly intended for television transmission, and designed to prevent the modulating signal from appearing in the output circuit, comprises a pair of push-pull tubes biassed be-



yond the bottom bend of their characteristics. A third tube is connected across the plate resistance of one of the push-pull tubes. G. Krawinkel, Berlin. No. 440,474.

Tuning aid. To facilitate aural tuning an A.V.C. bias is derived which is dependent both on the signal strength and on the difference between the carrier frequency and the frequency to which the receiver is tuned. Murphy Radio, London. No. 440,494.

Class B system. To prevent distortion in a push-pull Class B amplifier due to variation of anode supply voltage, the grid bias is varied in dependence on the anode voltage. Telefunken. No. 440,612.

Regenerative circuit. A tickler feedback circuit, the tube operating on the lower bend of its characteristic and including in its anode circuit an ohmic coupling resistance having a positive temperature coefficient such that increase in anode current to the value at which self-oscillation begins is prevented. W. Neumann, Kolberg, Germany. No. 440,856.

Synchronizing. The synchronizing signal consists of an oscillation with a frequency equal to a multiple of the line frequency, and is weakened or interrupted for a brief period to form the image-change signal. D. S. Loewe, Berlin. No. 442,333.

Television. A saw-tooth current generator comprises a back-coupled tube with an inductance coil in its plate circuit, the current through the inductance coil rising gradually during the trace portion of the wave, and falling rapidly to zero when the conditions are changed by saturation or by a synchronizing signal. Marconi Co. No. 442,334.

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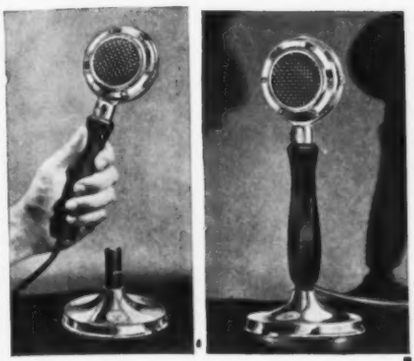

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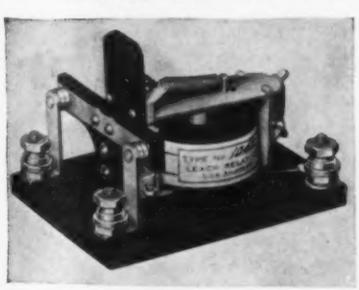

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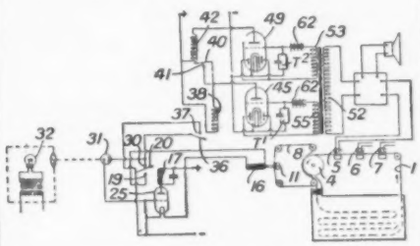
A.V.C. system. Voltages for A.V.C. are derived from a point on a high resistance and a point on a high voltage supply, the cathode of a diode detector being connected to a point on the supply and the anode to a point on the resistance having the same potential in the cathode in the absence of detector current. H. A. Wheeler, Hazeltine Corp. No. 441,171.

Record device. In a system for automatically controlling the starting and stopping of sound-reproducing announcement or record, there is provided



with relays a pair of double-diode-triode tubes which are controlled through different time-constant circuits by the output currents from the sound-reproducing apparatus. Marconi Co. No. 441,479.

Television circuit. Unrectified high-frequency potentials of a modulated carrier are applied directly to a Kerr cell which, having a characteristic symmetrical about zero voltage, permits the effect of full-wave rectification to be obtained. E. E. Wright and Baird Television. No. 441,505.

Superheterodyne. An A.V.C. receiver is provided with a local oscillator operating at the intermediate frequency which provides for homodyne reception and which, when the receiver is tuned to a frequency within a predetermined amount from that produced by a received signal, is locked with the intermediate frequency and releases a muted tube. Marconi Co. No. 441,582.

Tuning indicator. In a superheterodyne having A.V.C. and a substantially rectangular high or intermediate frequency response characteristic a sharply tuned circuit is coupled to the intermediate frequency amplifier and connected to a tube operating a resonance indicator. Philadelphia Storage Battery Co. No. 441,612.

Interference elimination. To eliminate interference from stations closely adjacent in frequency to the desired signal, the high-frequency couplings and the intermediate frequency stages of a superheterodyne are broadly tuned to almost uniform response over a band 14 kc. wide, the interference being removed by a wave-trap between the rectifier and loud-speaker and tuned to the frequency difference between adjacent carriers, for example, 10 kc. H. A. Wheeler, Hazeltine Corp. No. 441,970.

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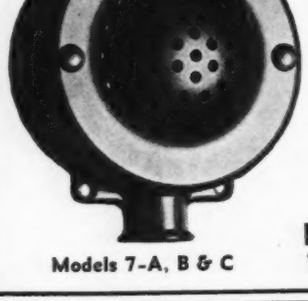

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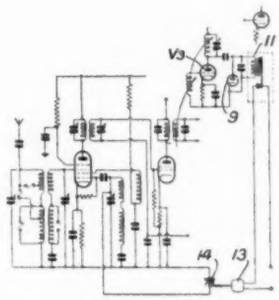
Automatic tuning system. In a superheterodyne the production of an untrue intermediate frequency causes a control current to flow to correct the



tuning of the receiver. The magnitude of the control current increasing as the receiver approaches resonance and ceasing at a point near resonance. E. K. Cole, Ltd. No. 441,691.

Directive system. In a direction-finding system, a visible and continuous record is taken in such a way that the direction finding minima are repeated in regular succession and alignment so that they can readily be identified and distinguished from the false minima due to fading. R. H. L. Bevan, etc., Portsmouth. No. 441,770.

Modulating system. In a modulating or demodulating system employing non-linear impedances in a balanced bridge network an adjustable resistance is provided to adjust the input voltage in each network so as to produce a balance in the output. G. E. Co. No. 435,201.

Superheterodyne circuit. To eliminate image frequency interference in a heterodyne receiver, a mixture of incoming signal energy and local oscillation is applied to each portion of a double detector system, the phase relation between the signal and local oscillation applied to one portion differing from that applied to the second portion, while an additional relative phase shift is produced between the output energies from the two detectors before they are combined and passed to the next stage. The phase relations are so chosen that the outputs from the detectors cancel in respect to image frequencies. C. W. Hansell, Marconi Co. No. 434,902.

Noise control. A muting bias applied to a signal detector is neutralized by the rise in potential of an electrode of a glow discharge tube used as a tuning indicator when the received signal strength reaches a predetermined level. A. C. Cossor. No. 437,538.

Intensity control. To obtain television images with a correct average intensity, the voltages representing variations from point to point of the picture and the very low frequency and direct-current potentials representing the mean intensity of the picture are amplified separately and subsequently superposed. Loewe. No. 439,164.

Tubes at Work

(Continued from page 38)

well sealed at its outer end by a mica disc to prevent foreign material from entering the assembly.

The high electrode of the unit is connected by a shielded lead to the input terminals of a special amplifier. This amplifier has a voltage gain of approximately 100,000 over a frequency range of 3 cycles to 20,000 cycles. The input tube is operated with very reduced supply voltages and due to these operating conditions has an input resistance of about 1,000 megohms. The output of the amplifier is connected directly to the vertical deflection plates of the cathode ray tube. A calibration source is provided so that the gain of the amplifier may be adjusted to known levels.

The horizontal deflection of the oscillograph is obtained from the timing axis oscillator which is synchronized with the engine rotation by a special synchronizer unit. A small alternator consisting of a six-tooth gear-like rotor revolving between the two poles of a permanent magnet on which is wound a pickup coil furnishes the synchronizing impulses. The pole pieces may be rotated through a small angle to frame the pressure diagram on the screen. The alternator is contained in a shielded cabinet which may be mounted on the engine frame, and an extension shaft connected to the crankshaft of the engine.

Mounted on the same shaft with the synchronizer rotor is a two-pole rotor of a marker alternator. This alternator, similar in construction to the synchronizing alternator, has its pole piece shaped to produce a very peaked voltage wave. The pole pieces are so mounted that they may be rotated 180 degrees around the shaft. The voltage generated by this alternator is introduced into the grid circuit of the last amplifier tube of the pressure amplifier and a small peaked wave is thus superimposed on the pressure diagram and appears at two points 180 degrees of rotation apart. By rotating the pole pieces these markers may be shifted to any position on the pressure diagram and any engine crank position thus indicated.

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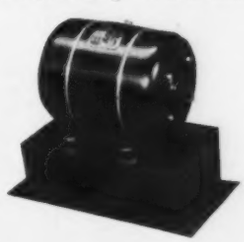

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